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Back-Lash in Engineering Education.

President Schurman's call for a broader training for engineers, upon which brief comment was made last week, ought to arouse active interest and should lead to reforms. To put the matter plainly, a four-year technical course taken from the datum plane of the ordinary collegiate admission requirements fails to put the graduate where he ought to be. Modern science has expanded so rapidly that the best training of the engineer demands more time than is now comfortably available for it. And at present the difficulty is becoming every year more serious. There is a strong feeling among thoughtful educators that for a man to make the best of himself he must have something more than mere technical details in his college course, and the available time is scant even for these details, as the courses are generally arranged. President Schurman's remedy is boldly to increase the length of the course, taking five to six years for it instead of four. Two other ways leading to similar results are open; first, raising the admission requirements; or, second, making the technical course proper essentially post-graduate as Harvard University has done in the case of the Medical School. All these roads lead to practically the same point, a substantial increase in the total time required for a thorough engineering education. It does not seem probable that those who are to be educated will take kindly to the proposition, which will start the young man in independent work at the age of twenty-five to twenty-seven, instead of at twenty-three or so.

Technical education has, as a rule, been built up from the earlier non-technical work in no very systematic way. Courses have been piled one upon another until the aggregate has become burdensome. And going back of technical training, the same kind of unsystematic, time wasting aggregation, bad even if carefully done, burdens the earlier years of preparation. Before adding one or several years to the total, would it not be wise to go down the line and eliminate the back-lash in the mechanism so that the student can be pushed steadily forward, on a piston lift as it were, instead of being pried and jacked up over the present irregular and rather rickety falsework? In the lower schools it is hardy too much to say that indirection reigns supreme. Solemn-visaged "educators" prate by the hour about "natural methods," quite forgetful of the fact that a very large part of the intellectual advance of the human race is due to its success in improving upon these methods. The sad result is that, almost from the beginning of school life, the victim is being dragged over roundabout paths. Nowhere is this tendency more conspicuous than in the study of mathematics, the foundation of engineering. Two or three years of school time are wasted, for example, in pottering over utterly useless ramifications of common fractions. How often does the practical (or theoretical) engineer for instance, have to add 7119/1153 and 419/831, or reduce 0.114 71/79 to its vulgar terms? All the common fractions needed in any proper arithmetical work could be taught the boy of average intelligence in six months of schooling—for the rest leave it to the symbolic treatment of algebra later.

Algebra, which is the basis of all higher mathematics, should be brought into action as soon as its methods direct to the path of least resistance. Why waste brain energy in doing arithmetical "stunts" when algebra was devised for the especial purpose of making them needless? And, similarly, why deal in the further study of algebra with problems which belong fairly in the domain of trigonometry or analytical geometry or calculus? Such indirect methods are not even defensible as mental discipline, since the effort put upon them could be better spent in acquiring facility in attacking the same problems by more practicable routes. Analytical geometry and calculus are not difficult save as they demand facility in algebra, and were a really modern and scientific course in practical mathematics laid out the student, without spending an extra hour of time, would reach college with the elements of these branches thoroughly ground in and with the ability to pick the right method for the problem in hand as instinctively as he would grab the right club out of his caddy bag. As it is in mathematics, so is it elsewhere. If boys learned English grammar instead of wandering through the devious bypaths of so-called "language lessons," there would be fewer complaints of the incapacity of college students to write intelligently their mother tongue. Even more objectionable and time-wasting than these zig-zags along the path of learning are the gay excursions up educational blind alleys. If boys parsed more sentences and painted fewer pansies, learned more history and less rum-and-nicotine physiology they would come up as engineering freshmen with less need for apologies.

There is at least a year of worse than useless educational back-lash, even up to the time when the boy reaches the so-called high school. Here more trouble awaits him. As a rule, the teachers in these upper grades are competent and hard-working, but incapacitated by being cramped between the pressure of the college above and the wallow of the educational theorists below. There has been in the last two or three decades so large an increase in the elective possibilities of college entrance requirements that the demands upon the preparatory schools are very severe. The desire for so-called "enriched" courses, a species of effervescence from the grades below, has put many a stumbling block in the straight path through to the college, and the resulting deficiency in essentials often throws up upon the college a burden of training properly belonging in the preparatory school. The net result is that the student enters upon his serious work about a year behind time, and has then too little time for both a general and a technical training. The first step toward broadening and strengthening the technical courses is the expurgation of tommyrot from the lower schools and the alignment of the preparatory schools for straightforward serious work, such as is done by the better German gymnasia. When this is done there will be a material increase of available time in the university. A broader course there is highly desirable, as President Schurman says. If the time set free in the manner just indicated is not sufficient for such broadening, an extra year may have to be added, but a year saved and well utilized ought to bring about a great change for the better. It would certainly be a step of dubious expediency to lengthen the university course without an attempt to strengthen its foundations.

The Modern Highway.

It has become generally recognized, both at home and abroad, that our highways, as they have been constructed in the past and even the best macadam roads of to-day, will not withstand, without rapid deterioration, the concentrated motor traffic to which they have been subjected since the advent of the automobile. The necessity for some radical change which shall involve an improved method of construction or the introduction of some means of protection and preservation is so apparent that the subject is receiving very general attention. But a short time ago in France the Minister of Public Works was authorized by the Cabinet Council to take the initiative in calling an international congress to consider the maintenance of roads suffering from motor traffic and for devising some means for adapting them to the new conditions which they must meet, and an equal interest has been taken in the subject in England. Massachusetts, always a pioneer in such directions, has devoted much attention to the problem of the protection of its elaborate system of highways and parkways, and what has been done there has been watched with the greatest interest. No one has recently gone over the Revere Beach Parkway, a stretch of three and a half miles in the suburbs of Boston, without remarking on its excellent surface and entire freedom from dust. In the same way the manner in which the dust has been suppressed on Commonweath avenue and on the park roads under the Boston Park Department, by the application of oil emulsions, has attracted attention. As to the cost of these undertakings, and that of their maintenance, there has been a great curiosity, which has been recently satisfied by the facts given in a series of papers presented last week before the quarterly meeting of the Massachusetts Highway Association in Boston, an abstract of which appears on page 570 of this issue. These data are of extreme interest to all who construct, maintain or use our roads, and they speak for themselves, but there are one or two points to which particular attention should be drawn. The very startling fact is announced and confirmed by several observers in Massachusetts that a macadam road of the best form of construction when subjected to motor traffic will last, at the most, when unprotected in any way, but two years, while, under less favorable conditions, near Lynn, a mile of almost perfect roadway had to be resurfaced after a year. The importance of the problem of maintaining the highways of that commonwealth is, therefore, apparent, even if the state of affairs is not as serious in other localities in regard to which as complete data are not available.

That something can be done to prevent the destruction of macadam roadways by the application of tar and similar substances, and at a cost which is not prohibitive, is very convincingly shown by the data in regard to the Revere Beach Parkway and the macadam roadway in Lynn. The cost of the treatment of the former averaged but 7.3 cents per square yard in 1907, while the maintenance of the work of 1906 averaged, for the entire surface, only 3.5 cents. At Lynn, the cost of tarring was 8.7 cents. With greater experience and with better facilities for working, this will, no doubt, be reduced. The results are such as to encourage further trials. Data in regard to the further cost of maintenance, after two or more years have elapsed, will be looked forward to with much curiosity.

It is of interest to note that roads with gravel surfaces are pronounced more satisfactory for motor traffic than macadam as constructed in Massachusetts, that such roads are more susceptible to treatment with oil, and that gravel or even sand is regarded as superior to crusher screenings as a covering for the tar after it is applied to the road. In France, it must be remembered, sand or the sweepings from the road itself, as it is cleaned before the tar is put on, is the material in use, although it is not spread until at least twenty-four hours after the tar to permit of its absorption. The Massachusetts practice of following up the tar at once with screenings cannot be the best unless the application is so thick that it is sufficient to work up through the screenings under traffic, and such an amount was suggested by one of the speakers.

Massachusetts has done nothing, however, in the way of tar macadam, with the exception of a small experiment of three or four hundred yards in Watertown, and data are sadly needed as to the value of this form of roadway. As properly constructed in England, especially with slag and crude coal tar on the Thames embankment, it has given some satisfaction. Recent experiments in this direction in New Jersey will be watched with care, and will, perhaps, enable us to determine whether the treatment of the broken stone for the second course and for the surface with tar before it is rolled will repay the additional expense involved. It certainly gives the road more elasticity and makes it, to a certain degree, more waterproof.

Another very striking point brought out at the meeting is the great relative economy attained by the Boston Park Department by the use of oil emulsions, as compared with water, in suppressing dust on the park roads, the saving being in the neighborhood of 50 per cent., or $333. per mile, while a distinct binding effect is observed in the surface, as the oil accumulates from the numerous sprinklings.

The papers read at the meeting are a most valuable contribution to the problem of the protection of our roadways and the suppression of dust, and are worthy of very careful study on the part of our road engineers.

The Conservation of Water.

The California case reported a fortnight ago in The Engineering Record, wherein the right of the State to regulate the use of artesian wells was affirmed, awakens a train of thought of serious import. The day is not far distant in which the water supply for the purposes of power and irrigation must be conserved with no small degree of care, and the privileges of individuals must be subordinated to the welfare of the community. In the arid portions of our country long strides have already been taken in this direction. It is hard for those who dwell in a well-watered region to realize how vital is the issue. Those, however, who have seen deserts in California or Navada or Idaho turn at the magic touch into marvellous gardens understand the significance of the decision just rendered. Fancy the situation were all the world arid save for the help given by the mountain snows and a few precious showers. If the ingenuous speculations of Professor Lowell be true, the inhabitants of Mars must have a code of water laws more complete than anything for which this planet can furnish a symbol. It may take well nigh measureless time for the earth to lose its water vapor, molecule by molecule, but the time is already in sight when the diminishing coal supply and the extremes of flood and drought due to denudation will combine to demand action for self-preservation.

One of the features of the California case was the attempt to defy the authority of the State by hiding behind the poor overworked misconstrued Fourteenth Amendment. It furnishes a strange example of an enactment made within the memory of the jurists who interpret it to serve a specific purpose, which they and all men understand, and which has been applied chiefly not to the protection of the grievously oppressed, but to the bare use of individual or corporate adventurers halted by the arm of the Law in attacks upon the rights of the community. In this instance, fortunately, a decision of the United States Supreme Court furnished a precedent directly applicable and affirming the rights of the community in subterranean water by whomsoever the overlying strata might be held. The common rights in "great ponds" and in navigable streams seem also to be beyond the grasping reach of individuals, and the common interest of riparian owners in other streams has been over and over confirmed by statute. It may be pertinent to go a step further and to inquire how far a man is at liberty, for his own private gain, to damage his neighbor's water supply. Has a perverse holder of land the right to injuriously deprive his neighbor of the natural flow of the stream? To press the question home is the holder of a portion of a watershed not liable for the use he makes of it if that use injures others, and is not the State well within its rights in restricting such injurious use? In the case here considered the Judge stated, "it is settled law that all property is held subject to the exercise of the police power," and this power has been repeatedly exercised to protect all those things in which the community has a contingent interest.

In the case of the water supply for power or irrigation, such interest has been clearly and fully recognized. Would it not be well within the proper powers of the State to prevent such indiscriminate denudation of the watershed as would injuriously affect the natural flow of a stream? The questions of fact in such a case may be somewhat intricate. In some instances denudation is permanent unless checked by deliberate reforestation, in others the effect is temporary and the damage is in part naturally repaired. Yet the situation to-day is a serious one, taking the country as a whole, and it is certainly pertinent to inquire whether there is not some more prompt and effective way of preventing irreparable damage than by creating forest reserves. It seems to be well established that the value of forest lands is enhanced by careful management, and not a few large owners of such lands are working them with due regard to the future. If cutting is done in accordance with the principles of sound forestry, the damage to forested watersheds is negligible and the situation may even be improved. It looks very much as if there were a fair opportunity for the State to step forward and say to those holders of forest lands who misuse them: "You shall not so deal with your holdings as to damage the rights of the community to the natural flow of its streams, any more than you are at liberty wantonly and injuriously to divert these streams where they pass over your holdings." The State of New York has done well at last to conserve its public lands and hydraulic rights. Why should it hesitate to prevent damage to these rights by the misuse of private lands? Forestry laws cannot be regarded as confiscatory, but only as regulative, and in the existing state of affairs they seem absolutely necessary to the future welfare of the community, which, however neglected by individuals, it is the duty of the State to guard.

The Proposed Henry Hudson Memorial Bridge at New York.

The proposed Henry Hudson Memorial Bridge as a masonry structure with its main feature a reinforced concrete arch of 710 ft. clear span is one of the boldest ideas of modern engineering. It was described in the Current News Supplement of the last issue of The Engineering Record. While it is not impossible that some of the minor architectural features of this new design may be criticized, it scarcely seems probable that such dignified, graceful and structurally effective plans for this great memorial bridge will fail of approval of the Art Commission. It does not often happen that the natural features of a location afford such a remarkable opportunity for a monumental bridge as do the surroundings at Spuyten Duyvil, and although various types of structures may harmonize with the setting of the bridge site, there can be no question that the masonry arch is one of the best. The massive dignity of the masonry arch, simply treated so as to give well-balanced and graceful proportions, combines both beauty of outline and structural force. The Bridge Department of the city has therefore acted with sound judgment and good taste in adopting a homogeneous composition of the masonry type, after being convinced of its structural practicability for such a large span.

The monumental character of masonry construction has been fully recognized for centuries, but never before in such a striking manner. The topography at the chosen crossing of Spuyten Duyvil valley affords an opportunity for giving the main arch a relatively great rise, which permits the use of a much longer span than would otherwise be feasible. It has been assumed by some engineers that the limit of length of an arch of masonry of any kind is about reached in existing structures; in fact, it has been assumed in some cases that it would not be feasible to build even a reinforced concrete arch of a materially greater span than about 350 ft. In reaching this conclusion, the influence of a great rise has obviously not been sufficiently recognized. The 220-ft. clear span of the Cabin John bridge held for many years the primacy of length, then came two European masonry spans of 275 and 295 ft., followed closely by the 256-ft. concrete arch in Philadelphia. Apparently no engineer has satisfied himself that far longer spans of stone and concrete arches than those mentioned were entirely practicable where the local conditions afford the required rise.

It would probably be quite feasible to construct a granite arch of the span and rise found in the proposed Henry Hudson Memorial Bridge, but such a structure would be enormously heavy and prohibitively costly. A thoroughly effective combination of steel and concrete, however, makes the design of this 725-ft. span, from center to center of springing joints, a matter of ready computation and relatively low cost. The basis of such an important problem in design is obviously to combine the steel and concrete so as to develop completely the supporting capacity of the former. As indicated in the description of the plan published last week, it would seem that the most effective feature of the design of the main arch as a structure is the manner of distributing the steel throughout the great reinforced concrete rib. Each unit of four steel angles is thoroughly latticed to form a steel column in itself, and all units are so tied and braced together throughout the entire mass as to constitute not only an effective steel rib, but also a continuous interior banding of the concrete, so as to enhance largely its resisting capacity. This latter feature is in its effect the same as that which governed the design of the compression members of the Thirty-Ninth Street Building from which this journal is issued. The principle of binding together a mass of concrete and thus increasing its carrying capacity by an artificial system of steel running through all parts of it, and at the same time creating thereby a perfect column effect with that steel, is essentially new and in the highest degree effective. It gives to the resulting combination of materials the toughness or tenacity of steel construction with the ordinarily low percentage of steel in reinforced concrete, and permits the use of concrete under the most advantageous conditions yet devised for that material.

The criticism has been made by a New York newspaper that the great arch of this new plan is too experimental to satisfy the requirements of assured safety in such a public work. A 725-ft. arch is certainly unprecedented, but so is any advance on what has hitherto been accomplished. While the proposed construction is bold, it is based upon tried details and processes, and is only an adaptation of proved materials and procedures, established by successful use in actual construction, to a structure whose dimensions exceed those of any masonry bridge already built. It is not in any sense experimental. The general type of reinforced concrete arch has already been employed time and time again, and there is no substantial reason whatever why it should not be employed in this special instance, to which it is so eminently adapted. Reinforced concrete has now been so extensively and successfully used for so many years that its permanent place among the best structural materials available to the architect and engineer is conclusively assured.

The Bridge Department has proceeded with wisdom in providing for four subway tracks below the roadway floor. A rapid transit route has already been tentatively laid out with a view to using this structure, and it is bound to become a part of one of the rapid transit routes to the north of Manhattan Island. It would be a grave mistake to build this bridge without ample provision for subway tracks and the additional cost involved, whatever it may be, is more than justified, it is demanded for a pressing public need. The main architectural treatment of the plan is excellent, to the engineering eye, in that it is simple and dignified. This observation is particularly applicable to the provision made for the subway tracks. In fact the whole project is thoroughly monumental in character and, if executed, will probably rank among the finest public works of the present time.

The Time Element in Industrial Efficiency.

Efficiency of production depends upon many factors. The cost of material, the expense of transportation within the plant, cost of power and of labor must all be cut to the lowest point consistent with reliable and prompt service if the work of the establishment as a whole is to be effective to the maximum pitch possible with each particular combination of men and equipment. In the power plant a single bad leak in a high-pressure main carrying superheated steam nullifies the economy of the best boilers and engines, and in the industrial plant, where power is but one element of production cost, failure to keep the stock moving from process to process invites an economic waste that may easily be several times as important as the exact make of turbines or gas engines qualified to produce a kilowatt-hour on the smallest coal consumption. The sense of proportion was never more needed in the conduct of large industries than to-day.

It would be idle to deprecate efforts to solve any single problem of production economy. A dollar saved at the coal pile is as valuable as a dollar saved in labor otherwise wasted, but the largest leak should be stopped first. A case in point is found in the years of study given by engineers to the perfection of prime movers, generators and switchboard appliances in the face of the complex uncertainties of the boiler plant. The day has come when the cutting off of half a pound of coal per kilowatt-hour by the scientific study of boiler installations, relations of draft and grate design to fuel quality, and the frequency and manner of firing is considered of even more importance than the reduction of one or two pounds in the steam consumption. Both ends of the plant now stand a fairly even chance of receiving proper study by order of progressive executives. The parallel in the large industrial plant follows in the enlargement of the engineering staff's analytical duties to cover the entire range of production from the storehouse to the side track. In some plants a separate development may be needed to study the problems of production efficiency, but whatever be the form of the organization, there is no doubt about the value of technical methods in the analysis of processes, including both graphic and tabular records.

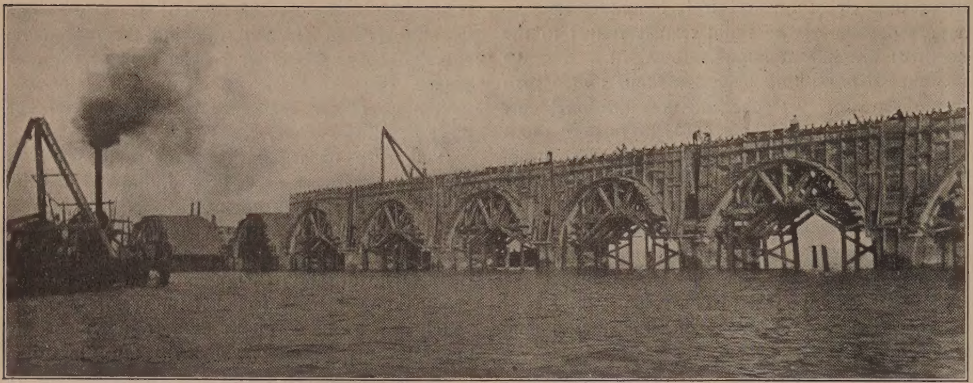
In approaching the general problem of production betterment from the standpoint of the engineer, the time element will often be found the most indefinite of all the factors which enter manufacturing cost. Cost of material and power, as well as administrative, sales and general expenses and fixed charges in the investment may be accurately ascertained; and the cost of labor will be known fairly closely with first-class accounting. A surprising absence of accurate data as to the average time each process and handling of the stock ought to require is very generally felt by the investigator in this field, however. Personal opinion will advance estimates enough from department heads, but there is rarely the same careful tabulation of processes by minutes and seconds, allowing for reasonable steadiness of application on the part of the employee, that there is, for example, in the collection of power costs per department and per piece handled.

It is easy to argue that stop-watch tests on separate processes give little indication of the continuous rate of production which may be expected from a shop force occupied in the manufacture of duplicate parts of machinery, and there is no question that a more intense rate of production will be expected if the results of stop-watch tests alone form the data from which output rates are to be established. On the other hand, the stop-watch test sets a limit, and if averaged over a long series of operations will be of great assistance in additions of separate departmental periods, taken in conjunction with counts of pieces turned out per day or week. Space forbids the extended pursuit of this theme, but the fact remains that the stop-watch test sufficiently repeated by the engineer investigating economy of production has in numerous instances brought to light conditions of surprising inefficiency at some stages in the manufacturing cycle, particularly in the fields of inter-department transportation and assignment of the product to its proper place at the machine tool. It is certainly no more arbitrary to establish an average time in which a piece of work instantly repeated should be turned out by machine tools and transferred from one department to the next over a fixed course than it is to settle the maximum turning speeds of a given tool steel in the high-speed lathe for a fixed quality of stock. The attention given to forcing production by the adoption of high-speed tools, the rebuilding or replacement of machine frames for heavier strains, the use of abrasives in place of cutting tools and the perfection of hoisting facilities are all moves in the direction of time economy, which affects both labor, cost and works capacity.

More accurate registration of time cards is desirable in many plants, for experience at the bench and tool clearly shows to every close observer the opportunity for gross inaccuracies to enter here. In a plant devoted to the manufacture of a single product, the time card presents less chance of serious average error, but in an establishment where the work varies in type, as in the manufacture of boilers of different styles, a time card error of 15 minutes multiplied among several caulkers or riveters is a point worth rectifying at the prevailing prices of skilled labor. The actual sum in a particular case may be small, but the point is to secure the most accurate figures of cost per job consistent with the conditions, eliminating every readily apprehended error. Closer bids can be made for this quality of data.

Aside from the attractiveness of time-saving through careful study of the legitimate duration of separate processes and the shortening of these when feasible, enforced by proper supervision, there accrues from such investigations valuable knowledge of the capacity of departments to handle rush orders. When the delivery is the deciding point on a contract, the ability to figure production times without a heavy estimated margin for contingencies may be worth the cost of several years' routine observation of production rates from the analytical standpoint.

THE CONSERVATION OF NATURAL RESOURCES, which is so generally recognized as an important national problem, will be discussed next May at the White House. The President has invited all governors of States, members of Congress and the Inland Waterways Commission to meet then for a consideration of the subject from every point of view.



Spandrel-Wall Forms in Place

THE LONG KEY VIADUCT.

Description of a Two-Mile Reinforced Concrete Railway Viaduct.

By Wm. Mayo Venable, Division Engineer, Florida East Coast Ry.

The first and longest of the viaducts on the Key West Extension of the Florida East Coast Ry. is approaching completion. All of the piers are in, and there remain but a few arches and the filling in of the space between the spandrel walls in a part of the structure before trains can be run over it. This work, it is expected will be finished in time to allow trains to run to Knights' Key by Jan. 1, 1908. The actual concrete work will be finished about the last of November.

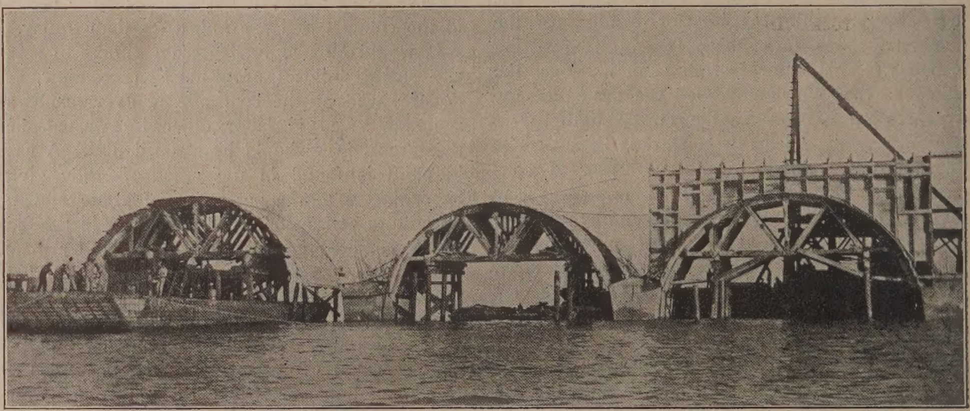
The Long Key viaduct is unique. It carries the railroad across an opening between Long Key and Conch Key, where the water varies in depth from 9 to 17 ft., and the tide flows from the Ocean to the Bay or the Bay to the Ocean with a velocity of from four to six miles per hour under ordinary conditions of weather, and with vastly greater velocity during storms or high winds. The velocity under severest conditions is difficult or impossible to compute, for the water from the Bay is actually picked up by the wind when a hurricane visits this region, and carried in the form of spray so swiftly that it cuts the face of a person exposed to it, and a man cannot look against it.

A storm of this character, blowing from the side of the Bay of Florida, occurred during the construction of the viaduct in October, 1906. There were then in place a number of piers, but no arches. All cofferdams and falsework were demolished, but the piers remained intact, justifying their design as capable of resisting the greatest possible attack that can be made upon them from the side of the Bay. From the Southeast, or Ocean side, the exposure is greater, the water being deeper. A liberal allowance has been made for the greatest possible wave that may come across the channel that lies between the keys and the reef, which interposes between the shallower waters about the viaduct and the Atlantic Ocean.

The top of the viaduct is 30 ft. above mean low water. The structure consists of a series of one hundred and eighty concrete arches, heavily reinforced with steel rods, with soffits of semicircular section. The radius is 25 ft., making the full span 50 ft. from pier to pier, and the height above mean low water 25 ft. Spandrel walls are built on each side of the arch, and rise to a height of 5 ft. above the soffit. Between these walls the space is filled with sand and marl dredged from the vicinity of the viaduct.

The bottom is a coraline rock, encrusted with a surface of harder material, somewhat like that which forms around a geyser. For the most part the bottom was comparatively clean, but in places it was covered for several feet in depth with a deposit of marl and sand. When the crust, which varied in depth from 4 in. to more than a foot, was broken through, softer material was encountered, which, though requiring blasting for its removal, was comparatively easy to penetrate with a drill, or even allowed of driving piling in the ordinary manner.

The situation and the conditions being unique, the methods adopted were likewise peculiar to this work and this locality. It was decided in the first place to conduct the work with a floating equipment, in spite of the obstacles of tide and the possibility of storm during a part of the year. All supplies and materials were of necessity brought to the work by water, and the facilities for storing them as well as using them had to be provided. Most of the supplies were brought to the work from Miami, Fla., a distance of more than eighty miles, by stern-wheel steamboats of the Mississippi River type, a number of which were bought by the company at the inception of the work. Piles and lumber came from the same port. Broken stone was brought in schooners all the way from New York, discharged at Knights' Key dock, constructed for the purpose of receiving such materials at Knights' Key, where boats drawing 19 ft. of water may be unloaded. From the dock the stone was conveyed to the work on barges, towed by the stern-wheel boats, the haul being about twenty miles. A considerable quantity of broken stone was unloaded into the water in a favorable location and reloaded for use later. Gravel for concrete in piers and seals was brought from Mobile; cement from Germany and New Jersey; sand from Bears' Cut, near Miami. Thus a very wide area was tributary to the construction.



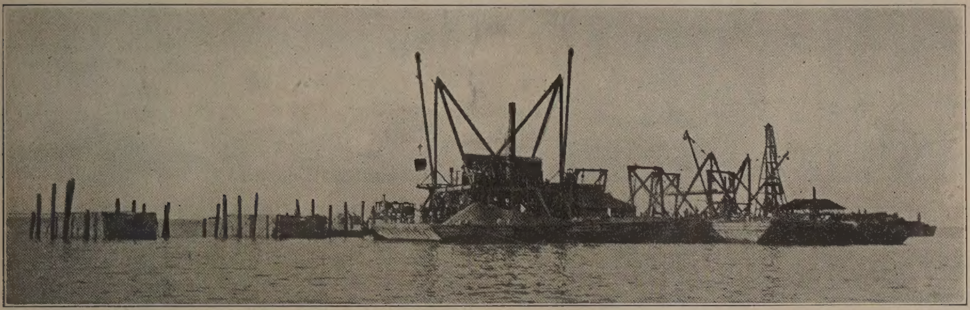
Placing Arch Centers and Spandrel-Wall Forms.

The method of placing the piers, while simple, was perhaps the most interesting and unique feature. The piers were of sufficient section to carry the thrust of the arches, to which they were firmly anchored by the reinforcing steel, so that they were inseparable from the superstructure. The reinforcing of the viaduct consists of two sets of ¾-in. Ransome rods, one set imbedded in the concrete near to the soffit and passing from pier to pier, and the other set imbedded in the outer portion of the arch and likewise extending from pier to pier. These two sets of rods are properly spaced and held the right distance apart by spacing rods, which likewise add some strength to the structure. Considerable steel is also used in the spandrel walls, both to prevent them from forming surface cracks and to make them add to the strength of the structure as a whole. As an additional precaution against several of the arches being demolished in case one should be destroyed by any accident, every fifth pier is made thicker than the others. The reinforcing not only joins every pier to the adjacent arches, but it is so disposed as to join all arches and piers in one continuous structure, so that any shock delivered to the viaduct at any one point would be transmitted to a number of piers. There are no breaks or hinges in the structure from one abutment to the other, a distance of about two miles.

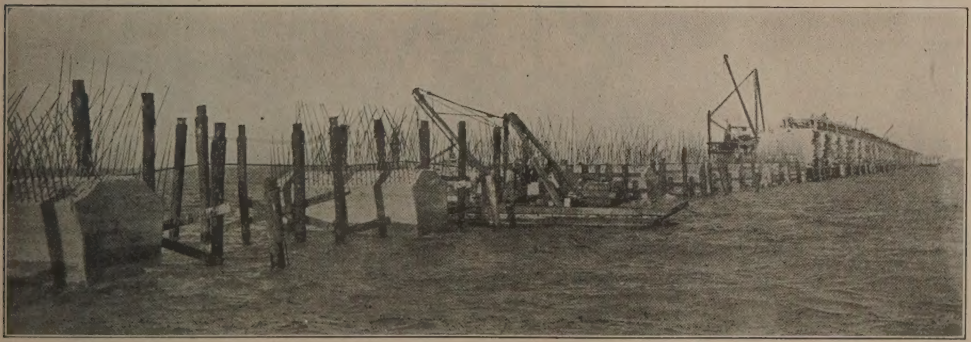
The method of placing the piers, to return to the subject of construction, was unique. Briefly stated, it consisted of lowering cofferdams to the rock bottom, the cofferdams being open at both top and bottom. Within the cofferdam after it was lowered and the bottom cleaned of sand or marl, was deposited through pipes a layer of concrete from 2 to 5 ft. in depth, according to the depth of water. This concrete was allowed to set, and the cofferdam pumped out to allow the placing of the form for the pier, and the subsequent work of concreting the pier. As the cofferdam sometimes rested upon marl or sand when first lowered, and sometimes rested on clean rock, and as there was a strong current, due to the tide, which changed direction while the preparation of the pier for sealing and the sealing were in progress, considerable trouble was encountered in executing this work, especially at the commencement, when the best methods had to be discovered. An attempt will be made to describe these processes with sufficient detail to make them understood in a general way, and to indicate some of the difficulties.

It was contemplated to anchor the piers to the bottom, either by blasting into the bottom or by driving piling into it to take up the shear that might be imposed between the base of the pier and the rock bottom, which was often quite smooth, though uneven. Of these two methods that of driving piling was preferred, although it was not definitely known before the work was undertaken that it would be found practicable. It had the advantage of not disturbing the hard crust of the bottom, of requiring less material, and of leaving a bottom easier to clean of loose material. It was found practicable, and piles were driven by a floating driver for every pier as well as to support the arch centers for every arch. Many piles for mooring purposes were also put down, and a number for temporary docks and other incidental structures.

The method of driving piles was as follows: A steel shaft, some 25 ft. long and 6 in. in diameter, was provided at one end with an enlargement to form a punch 8 or ten in. in diameter. The other end of the shaft was fitted with a socket to take a short piece of piling as a buffer between it and a steam hammer. This punch was swung upon the pile-driver, and was placed in position in the leads at each point where a pile was to be driven. It was then driven into the rock by the steam hammer, from one hundred to five hundred blows of the No. 1 Vulcan hammer being required to secure a penetration of from 3 to 6 ft., according to the hardness of the rock. In some places it was found impossible to secure over 18 in. penetration, this being insufficient to support a pile. In other cases, though such were rare, after one or two blows of the hammer the punch would fall 6 to 12 ft., as if it had broken through the crust into a cavity. Holes like these, when encountered, were found to be of very small section, as the punch placed only a foot or so from a position where it fell after being struck might refuse to be driven more than a foot or so. They appeared to be pipes in the coral bottom, filled with nothing but water.



Plant Ready to Place Concrete in Sealed Cofferdams.



Finished Piers, with Anchor Rods for Arch Reinforcement.

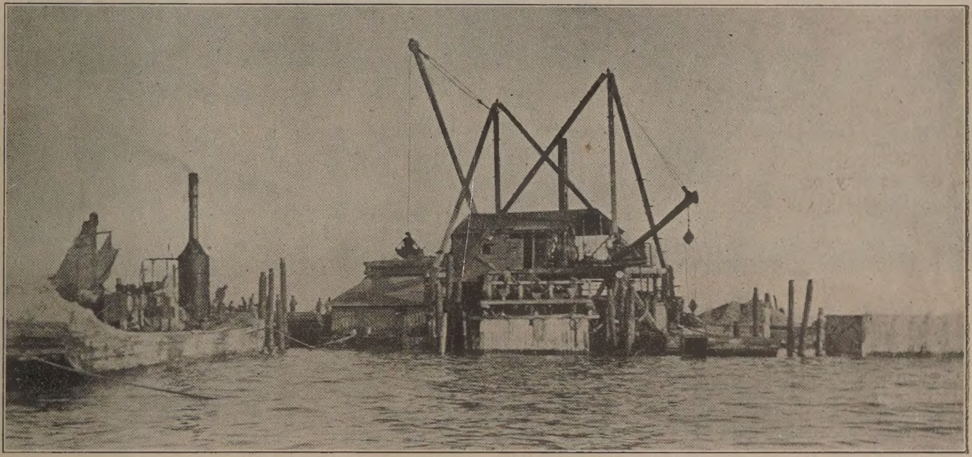
When the desired penetration of punch was secured, the punch was withdrawn from the hole, a process by no means easy until special rigging was made for it. The form of the punch also was an important factor in the ease with which it could be withdrawn. The pile was then placed in the hole prepared for it, and driven home with the driver, requiring from twenty to fifty blows. Many of the piles were cut to proper length before being driven and driven with a follower, so that they did not show above water until the cofferdam was lowered around them, sealed and pumped out for the pier work.

The cofferdams were made of four pieces,—two sides and two ends, constructed so that they could be taken apart at the corners by the removal of long pins. Each piece was composed of timbers lagged with pine planks 4 x 8 in. by 16 ft., and calked with oakum. The four pieces were assembled by a derrick on a barge, which, with a companion barge, was called the catamaran. The corners were made tight by canvas held across the uncalked joints by nailing strips. The completed cofferdam was then run out on timbers between the two barges, raised by blocks so as to swing free from the timbers and allow of their removal, and then lowered to the bottom in the proper place. It was then anchored in place by pull jacks and chains fastened to the guard piles or arch bent piles around it. Six jacks were used for each cofferdam.

When lowered in place, the cofferdam was protected against the tide washing underneath it by lowering sacks of sand around it, or by dredging sand to bank up around its bottom, when this was practicable. Its interior was then cleaned on the bottom by pumping out any marl, sand or seaweed with a centrifugal sand pump, after the material had been loosened by jetting. Failure to properly close the bottom against the tide, or washing away of the protecting sacks at the turn of tide, which sometimes occurred in spite of precautions, resulted in washing out a part of the cement from the seals subsequently placed. With the proper closing of the bottom of the cofferdam the greatest difficulty was experienced.

The sealing was done through three 8-in. galvanized iron pipes, mounted on a car which ran on a track placed on the cofferdam. Each pipe was provided with a hopper at its upper end, and mounted in such a manner that it could be readily raised and lowered by two men who were charged with that duty, so as to feed the concrete to the bottom without allowing the water to enter the pipe during the process of sealing. This was very hard work, and required skill and conscientiousness on the part of the men. Lack of skill in placing the concrete resulted in inferior sealing, owing to the concrete being deposited in such a way as to wash out a portion of the cement. The concrete itself, for seals, was mixed in the proportion of one and a half parts of cement to two of sand and four of gravel, and allowed to set an hour after mixing before being shoveled into the hoppers. All of the mixing was done by machine.

At the beginning of the work seals were allowed to set three days before the cofferdams were pumped out to place the pier forms; but later only two days were required. When pumped out, the cofferdams allowed men to descend, cut off the piles projecting through the seal at the proper height, place the pier form and the reinforcing rods. The concrete was then placed by one of the work-barges equipped for this purpose. It was mixed in the proportions of one part of cement to two of sand and four of gravel.



View during the Sealing of a Cofferdam.

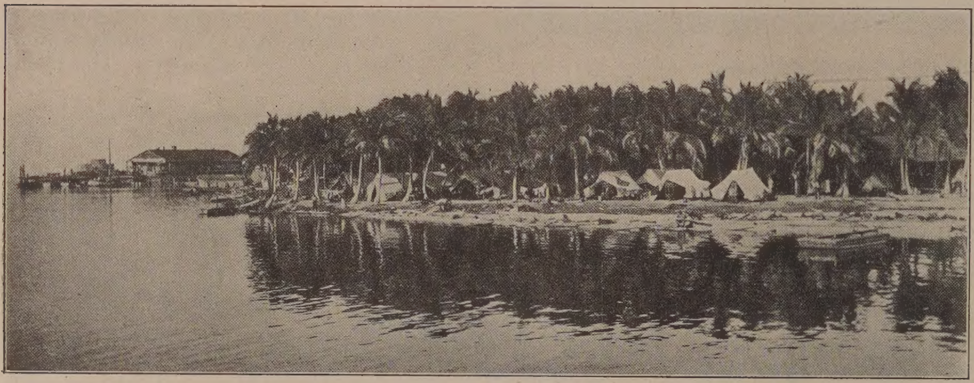
The work-barges employed for concreting were especially designed for this work. They contained a concrete mixer, with hoppers for sand and gravel, and two derricks, one for hoisting material into the hoppers and one for removing the concrete from the mixer to the work. These derricks were mounted with their bases about 16 ft. above the deck, and they had booms 50 ft. long, so that they were capable of placing the concrete wherever it was wanted, in piers or any part of the superstructure. They were likewise equipped with pumping outfits and electric light plants, for the work of concreting proceeded both by day and by night.

A few days after a pier was concreted the cofferdam and forms were removed, and at any convenient time thereafter the work of placing the arches was undertaken. This work on the arches was practically independent of the work on the piers, and was conducted with different men, different barges, and to some extent different materials. While in the piers only German cement was used, in the superstructure either German or American cement was permitted. The hesitation about using American cement in the piers was on account of doubt as to its ability to resist the action of salt water. The arches were concreted with a mixture of one part of cement, three parts of sand and five parts of broken stone.

In the arch-work the first step was the placing of the center. The centers, of which thirty-three were used in the construction of the entire one hundred and eighty arches, and left in good condition at the end of the work, were first assembled in the place where they were first to be used; but thereafter they were floated forward intact and placed for the arches by the use of jacks. After the centers were placed the spandrel wall forms were erected. These were made in panels, there being sixteen inner and sixteen outer panels to each arch. The panels were re-used many times, but they did not have the lasting qualities of the centers, being much damaged in removal. A small section of the spandrel wall form over each pier was built in place each time.

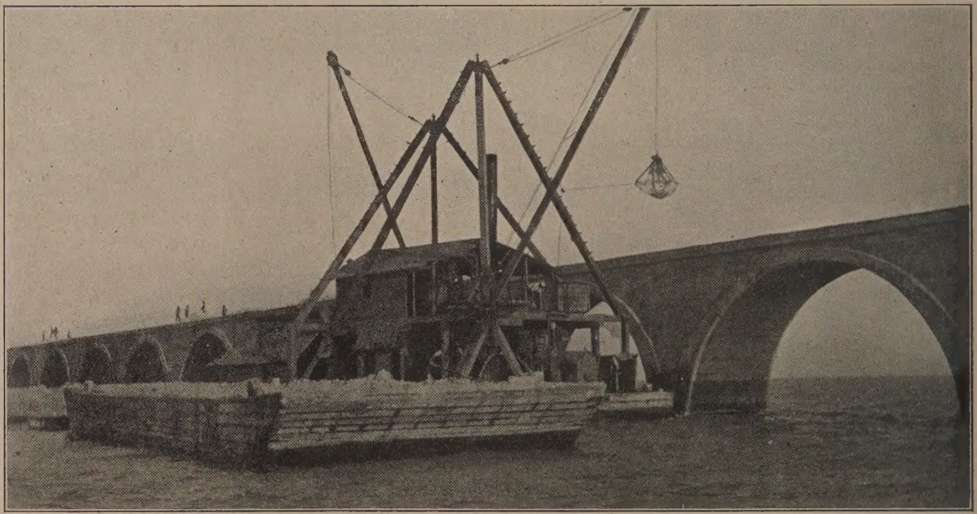
The concrete was placed in the arch ring and the spandrel wall at the same time, being commenced over a pier and carried out on each side thereof over the adjacent arch centers. Thus, an arch ring would be built in two operations, the first consisting of placing the concrete from one pier to a point about one-third of the distance around the arch ring, and the second beginning at the other pier and completing the other two-thirds of the arch. The place where these two operations formed a joint was selected so as to secure the least deflection of the forms during the placing of the concrete due to the loading. The method was very successful.

Long Key Camp, Seen from the Water Tank.


View of the Camp from the Viaduct.

The spandrel wall forms were removed at any convenient time after the concrete had set, it being the policy to remove a form only at the time that it would be needed ahead, so as not to encumber a barge with it until it was needed. The arch centers were left in place thirty days, to insure complete setting before loading. Thus a less number of spandrel wall forms was required, but these were in constant need of repairs.

After the forms were removed the space between the walls was cleared of all litter except such concrete material as spilled into it during the process of concreting. This material was used to bank about the drain tile that was placed in the top of the pier to drain the space between the walls. Thereafter the space was filled with marl and sand, material readily available in the vicinity, and at a portion of the viaduct so located that it could be dredged and deposited in place with a single operation of a clamshell bucket. But for most of the viaduct it had to be dredged in one place and barged and rehandled into place between the walls. Some experimenting was done to determine the suitability of this material for this purpose, with gratifying results.


Work-Barge Placing Filling between Spandrel Walls.

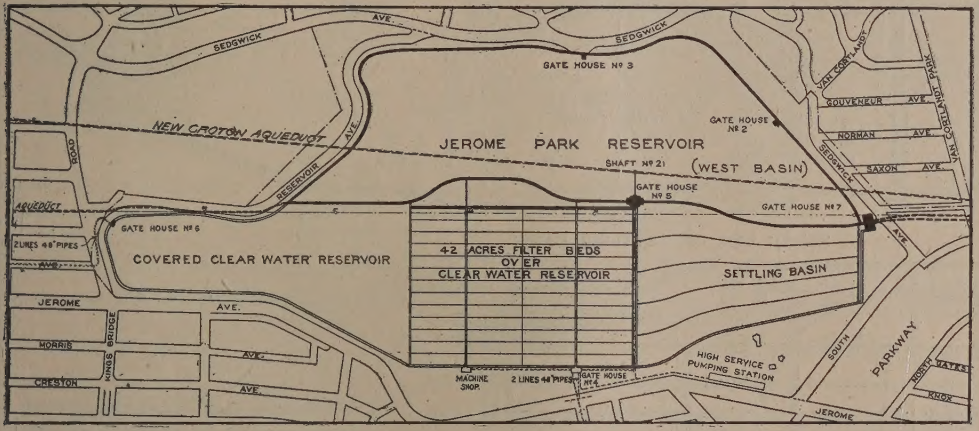
The handling of this work, many miles from any city, and far from any labor market, as well as from any depot for machine supplies, was in many respects more difficult on account of the isolation than the physical obstacles. The force employed on the viaduct varied from five hundred to eight hundred men after the work was under way. These men were for the most part recruited in New York, that is the laborers, many of the skilled men coming from other places. Quarters and subsistence had to be provided, and transportation from the camp to the work each day. The towage of the barges of material to the machines that were to use them was in itself a considerable problem, as was the acquiring and maintaining of a plant of such peculiar character, intended for use a short time only. The fact that this viaduct is itself but a part of a road containing equally unusual and difficult construction in other places, all under the same management as regards construction, and dependent upon the same transportation facilities, introduced elements not ordinarily met in equally heavy construction.

The camp provided was in a picturesque grove of cocoanut trees on the Southwest end of Long Key, formerly known as one of the worst places for mosquitoes on the Keys, but converted by clearing and some draining into a delightful spot. The land is but slightly above mean high water, and at times portions of it have been overflowed; but it has been kept in perfect sanitary condition, and no sickness has been known to originate there. Water for domestic use is brought from the Everglades, and is most pure and wholesome. Before railway communication was established in October, 1907, water, like everything else, was brought by boat, but now it is brought in tank cars. A well organized subsistence department, with headquarters in Miami, supervises the issue of food supplies over the whole of the road and procures the necessary skilled help in that department. At Long Key there is a bakery with a capacity of one thousand loaves of bread a day.

As all know, the enterprise is the peculiar interest of Mr. Henry M. Flagler, and owes to him its inception and the means of carrying it into execution. In execution, his interests are represented by Mr. J. R. Parrot, Vice-President of the Florida East Coast Ry., and the constructing engineer, Mr. J. C. Meredith, who has immediate charge of all matters, both of design and construction, of the extension from Miami to Key West. The writer's connection with the work is as division engineer, in immediate charge of the Viaduct construction. He took charge in this capacity in September, 1906, at which time a few piers had been placed, but no arches. Mr. M. F. Comer is general foreman, having been connected with the construction work from its start.

The Filtration of the Croton Water Supply of New York.

On March 28 of last year Mr. I. M. de Varona, chief engineer of the Department of Water Supply, Gas and Electricity of New York City, submitted to the Commissioner of the department a report reviewing previous recommendations for the filtration of the Croton water supply and advising the construction of filter beds above the roof of the eastern basin of the Jerome Park reservoir. In order to settle definitely the practicability of the plan, a further appropriation was made at Mr. de Varona's request, in order to make more complete studies and plans than the previously available funds permitted. Messrs. Rudolph Hering and George W. Fuller were retained as consulting engineers, Mr. William B. Fuller was appointed engineer in charge of filtration and a staff organized under his direction. An examination of all possible sites for filters showed the decided superiority of Jerome Park to all others, and plans for works there were developed in a general way, described by Mr. de Varona in a report about a year ago. Since that time the work has been completed, and last week he submitted his final report.



Plan of the Proposed Filter Plant for the Croton Water Supply, New York.

The research work on which the decisions were based in part was conducted at two testing stations. One was built by the Department to furnish information concerning the best rate of filtration of the Croton supply, and the other was constructed by private parties to demonstrate the value of the ozone treatment.

The Department's station essentially consists of sedimentation basins 10 ft. deep, 71 ft. by 25 ft., arranged by baffles in a series of compartments to represent as desired a period of sedimentation of from 4 to 60 hours. The filters consist of two rectangular beds, each about 15 by 30 ft., and having an area of about 1/100 of an acre. The filtering medium consists of about 26 in. of Cow Bay sand, having an effective size of 0.21 mm. and a uniformity coefficient of 2.62. The sand layer is supported by four layers of graded gravel of an aggregate depth of 16 in. Beneath these gravel layers are tile pipes to convey the effluent to the outlet, where the rate of filtration is governed by means of a series of calibrated orifices. The filters are equipped with gauges and indicating apparatus for recording all necessary data. A laboratory and set of coagulating devices are also provided, together with an adequate staff for operating the plant, securing samples and making analyses as directed. The laboratory building is about 18 ft. by 42 ft., and is located over and at the westerly end of the filter and sedimentation basins. The analytical work included both bacteriological and chemical analyses, as well as the ordinary tests to record the color and turbidity of the water before and after treatment.

The contractor for the testing station got the various devices in working order in March, 1907, since which date the tests have been carried on practically without interruption.

Just to the west of the experimental station the United Water Improvement Co. of Philadelphia erected a frame building and placed therein the necessary apparatus for a demonstration of their method of water purification. Work on this building began in December, 1906, and the first ozone was made on Jan. 12. Ozone was first used in the sterilizing tower Jan. 31. Essentially their method consists of the introduction into the water to be purified of a mixture of air and ozone, whereby the organic matter present is oxidized and bacteria killed.

Their plant consists of a mechanical filter of the Hungerford type, which treats water for the removal of its turbidity. The water so treated is then pumped to the top of a 38-ft. stack, 22 in. in diameter, and flows downward through the stack, while in the opposite direction there rises a mixture of air and ozone, admitted to the bottom of the stack by a special strainer or spreader. Reaching the bottom of the stack the water flows into a vertical pipe and rises to nearly the top of the stack, in order that the stack may be kept at all times full of water. The amount of water, air and ozone may be varied to meet the special conditions of the applied water.

The air is first cooled by passing through a refrigerator, to remove its moisture, as dampness causes trouble in the ozonizer. After this first refrigerating process, the cooled air is drawn into the ozonizer of the H. Blanken system, where, by means of an alternating current of 10,000 volts, 60 cycle, a portion of it is transformed into ozone. From this ozonizer the mixture of air and ozone is drawn by a compressor and forced into a pressure tank, from which is supplied the upward current of air and ozone in the sterilizing stack.

Aside from its magnitude, the Croton one differs from the majority of filtering projects, Mr. de Varona states, in that it deals with water supply from very large impounding reservoirs and not with the water taken from a muddy river, into which flows the sewage of various communities above the intake. The Croton water is distinctly easier to filter than many other supplies now being filtered in this country, except, perhaps, the supplies at Reading, Pa., New Haven, Conn., and a few other small plants. Some filters for water drawn from rivers, containing considerable sewage, silt and clay, have been generally operated at the rate of from two and one-half to three million gallons per acre daily, but carefully conducted investigations at the Lawrence Experiment Station of the Massachusetts State Board of Health, and at Cincinnati and New Orleans, and practical experiences at Reading, show that double those rates are entirely feasible for water less impure and, in fact, the investigations above mentioned, combined with the experience at Springfield, Mass., and at Zurich, Switzerland, show that a rate of ten million gallons per acre is feasible, provided the water is given a proper preparatory treatment. In the consideration of the Croton filtration project, much attention has been given to the use of a high rate of filtration from the view point of economy and efficiency, as judged by an adequate removal of disease germs, color, turbidity and objectionable tastes and odors.

A ten-million gallon rate per acre, as compared with a five-million gallon rate, obviously means a great reduction in the construction cost, which, in the present case, is represented by the difference between estimates of $7,600,000 for the higher rate and $11,500,000 for the lower rate. Many of the pipes and appurtenances would not be affected by these rates, but the filters themselves would be only one-half as large if the higher rate is feasible. The rate of filtration does not materially affect the quantity of water filtered between cleanings of the sand surface or the time required for a single cleaning, as the frequency of cleaning is inversely proportional to the rate of filtration. In other words, a higher rate means that a filter is out of service for a much greater portion of the time for purposes of cleaning and a much greater reserve area of filtering surface is required with the ordinary method of draining the water from the sand layer, scraping off the surface layer of clogged sand and filling the filter again before starting. For a project as large as that for the Croton supply, this reserve area of filters to compensate for the periods when the filters are out of service for cleaning is of much importance and has caused a careful study to be made of the improved methods of cleaning the filters.

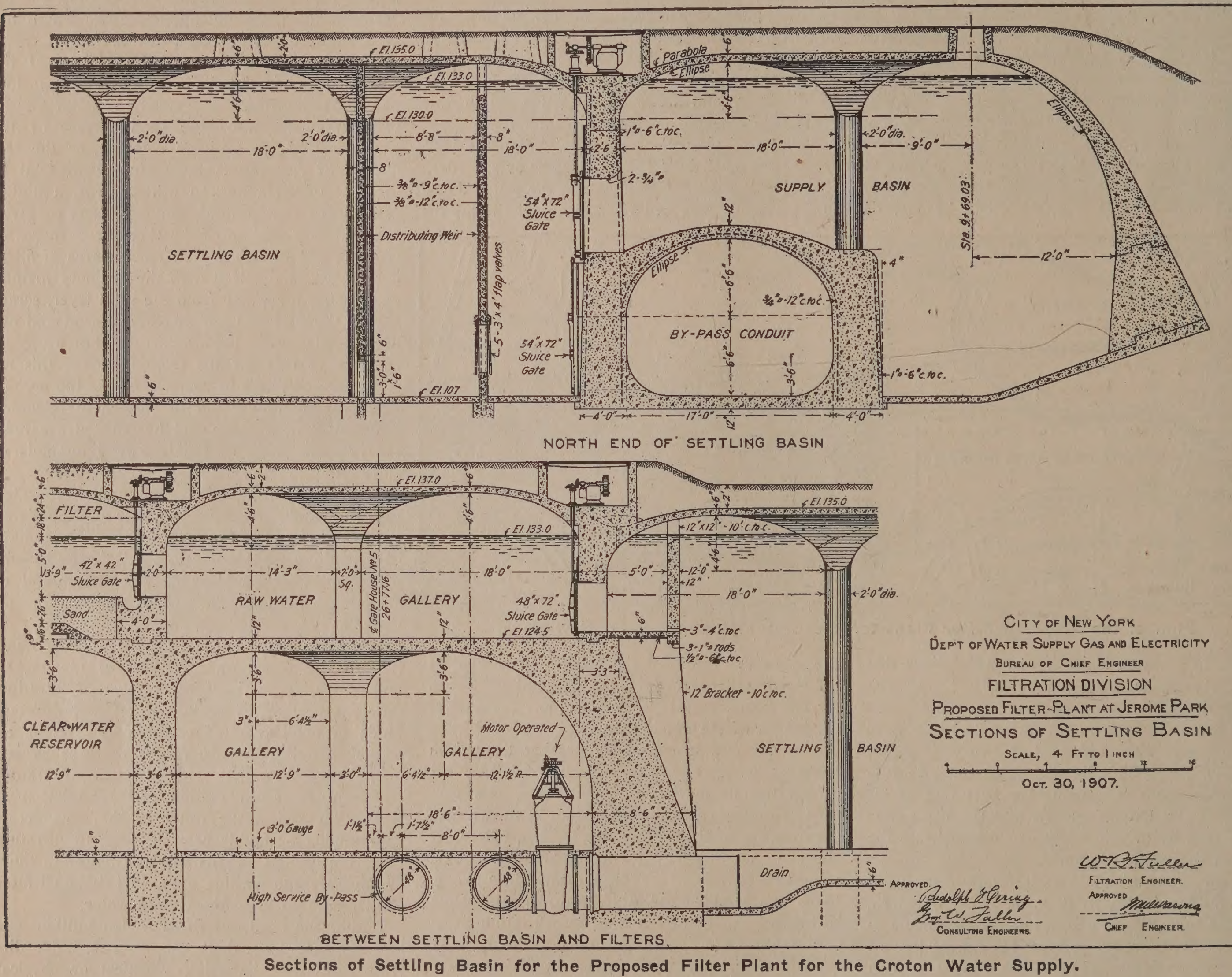
The better the quality of an unfiltered water, the easier and cheaper it is to filter and the higher is the permissible rate of filtration. Studies have been made along this line to ascertain the benefits of sedimentation with and without the aid of coagulants as a preparatory treatment for filtration.

Forty-five runs were made prior to the preparation of the report on the filters of the experimental station, with different rates of filtration, different periods of sedimentation and different kinds of application of coagulants, covering all possible conditions. The results of these experimental runs show that, with adequate preparatory treatment by sedimentation and coagulation at those times when the water in the aqueduct is very muddy or highly colored, rates of filtration up to ten million gallons per acre daily are thoroughly safe and feasible for a well designed filter plant operating upon the Croton water.

Within the limits of three to ten million gallons per acre daily, there was no measurable difference in the bacterial, chemical or physical quality of the effluent or any substantial difference in the volume of water filtered between cleanings, due to the rate of filtration. The initial loss of head increased in direct proportion to the rate of filtration, and with a ten-million gallon rate approximated one foot with a medium fine sand.

Sedimentation did not ordinarily prove to be of assistance during the period of these investigations, but undoubtedly there are times, especially in the winter and early spring, when the amount of mud or turbidity in the water will be sufficient to make sedimentation a distinctly helpful adjunct to the filtration plant. During these tests the bulk of the suspended matter in the water was due to algae growths, and these did not subside to any very great extent.

Studies were made both in the laboratory and in the operation of the basin and filters as regards the need and best manner of coagulating the Croton water. It was found impracticable to remove the color and other matters from the Croton water by the aid of lime and sulphate of iron unless applied in quantities prohibitively expensive. Sulphate of alumina in quantities averaging about one grain per gallon would effect a decided improvement in the quality of the filtered water for about eight months during the average year. During the remaining four months of an average year this treatment would be unnecessary. The cost of this coagulant would average about $1.10 per million gallons, and for this application a sedimentation basin will be provided, holding at least seventeen hours' flow, in order that the bulk or larger portion of the coagulated matter may be deposited before reaching the sand beds. The entire elimination of the coagula by sedimentation cannot be accomplished, nor is it desirable, and a considerable quantity of very tiny particles of alumina hydrate would pass from the sedimentation basin to the filters, where it would be removed at the surface of the sand layer.



Sections of Settling Basin for the Proposed Filter Plant for the Croton Water Supply.

After the filter got in normal condition, in April, the quality of the effluent regularly has been satisfactory as regards freedom from bacteria, turbidity and vegetable tastes and odors. The color or vegetable stain has been removed to an average extent of about 25 per cent. This removal would leave a noticeable color in the effluent for some eight months during the average year, and at times the discoloration would be very pronounced, when the water received no treatment other than by sedimentation and by filtration, as provided under our plans as already outlined.

In accordance with the adopted rate of ten million gallons per acre, it is entirely practicable with 42 acres of sand filtering surface to filter the present nominal carrying capacity of the two aqueducts, namely, 400 million gallons daily.

In the course of the investigations it was of the utmost importance to determine the most effective and economical method of washing and cleaning the sand, and for this purpose repeated trials were made of the Brooklyn method, successfully employed in a small scale under Mr. de Varona at the filter beds in Hempstead and Forest Stream, which offers some advantages over the usual method by scraping the sand, removing it, washing it and replacing it in the filters; and numerous trials have also been made of the Blaisdell machine for washing the filters without removing sand or throwing the filter beds out of commission.

The Brooklyn method consists essentially of allowing the water above the sand to drain until a depth of only about one inch remains above the sand surface. Outlets just above the sand surface are then opened and water is applied at one end and allowed to flow across the bed, the direction of flow being guided in these experimental filters by boards set on edge in the sand layer. As the water flows over the surface of the sand the layer is raked by men standing upon the sand surface. The depth of water flowing over the sand during this raking operation is about two inches. The raking and flow of water are continued until the water leaving the filter is practically clear. Water is then applied in the usual way and filtration resumed.

The Blaisdell machine, as here proposed, consists essentially of hollow revolving rakes incased in an inverted box, the whole apparatus being submerged and moved by suitable machinery from one end of the bed to the other. In its operation water is forced through the rake teeth into the sand layer, to be cleaned, to any desired depth, while the rakes revolve, and the dirty water is pumped from the enclosed box. If this machine be used there is no need of draining and refilling the filters or removing the sand.

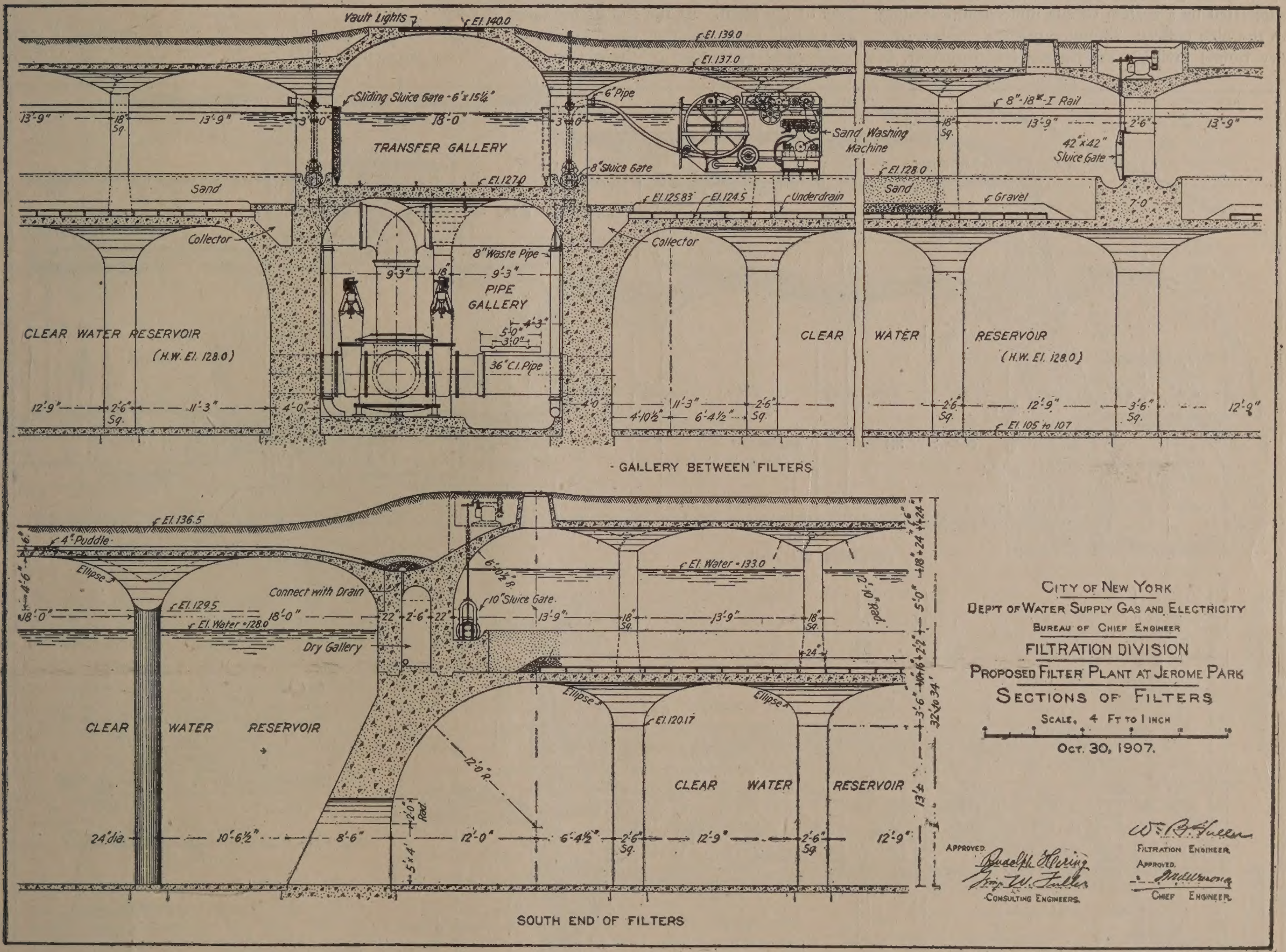
The results obtained from these trials show that either the Brooklyn method or washing by the machine are cheaper than the method hitherto adopted of scraping the sand, washing it and replacing it. The filters have been so designed that either the Brooklyn method or washing by the machine can be adopted for a sand layer with a comparatively uniform size of grain.

Owing to its efficiency in destroying germ life without injuring the water, ozone has for some time been favorably and extensively discussed in this country and abroad, as a possible adjunct of filtration, and some small plants have been installed and at times operated in Europe, but not with favorable results. The drawbacks hitherto to the adoption of ozone have been the unreliability of action and prohibitive cost of operation.

The United Water Improvement Co. made a proposal to install an experimental ozone plant at Jerome Park, claiming that whereas the usual production of ozone by other methods had not exceeded 16 grains per kilowatt-hour, with their new ozonizer they could readily obtain 85 grains of ozone per kilowatt-hour, thus bringing the cost of the process within practical limits. They also claimed that the system of a silent electrical discharge in their ozonizers absolutely secured continuity of action and reliability of operation.

Permission was given to this company to install, at their expense, a plant for the purpose of testing the merits of their method, the experiments for that purpose being, under the terms of the agreement, conducted under the immediate direction and supervision of Mr. de Varona and his staff. After the completion of their preliminary tests, he was officially notified by the company that the plant was ready for his tests, which were conducted from May 7 to May 31, 1906, after which date no further tests were made and the company ceased to operate the plant, and have been ordered to remove the same in accordance with the agreement.

The experiment showed that of the current used, about one-quarter was consumed by the refrigerating machine, one-quarter by the transformer and ozonizer and one-half by the compressor. It appeared that the color might be reduced from about 15 to about 5 and bacteria from about 100 to about 7, by the use of about 3,500 grams of ozone per million gallons, with an expenditure of about 800 kilowatt-hours. With electrical energy costing 2½ cents per kilowatt-hour, it appeared that under the conditions of the experiments the process was costing about $20 per million gallons, of which perhaps $5 represented the cost of ozone and the other $15 were chargeable to drying the air and pumping it into the water. During the whole time that the plant was in operation, it did not run a single day without stopping, a fact of itself sufficient to demonstrate the impracticability of using the proposed method of ozone purification as an adjunct of the filtration plant, regardless of its cost.



Sections of Filters and Clear Water Reservoir for the Proposed Filter Plant for the Croton Water Supply.

The conclusions reached from the thorough and detailed study of this matter and the practical results obtained at the experimental stations, are summarized by Mr. de Varona as follows:

The eastern and unfinished section of the proposed Jerome Park reservoir, on which work was suspended about two years ago, which has an area of 135 acres, affords the most favorable site for the location of the filter plant. (See illustration.) The marked advantages of this site over all others, especially in cost of construction and operation, were fully discussed in his report of Oct. 3, 1906.

The proposed plant is to have a capacity of 400,000,000 gal. a day, which is equal to the nominal capacity of the two existing aqueducts, and about 85,000,000 gal. in excess of the present average daily consumption.

The proposed site has been excavated approximately to grade. The filter plant consists of a settling basin on the northern section, covering about 37 acres, the filters consisting of 102 filter beds covering about 48 acres of the central section, with an effective area of 42 acres, and a clear water reservoir which occupies the southern portion of the site, covering about 46 acres. The clear water reservoir extends also underneath the filter beds.

The water is now delivered at the Jerome Park reservoir through the new and old Croton aqueducts, the height of the water line in the latter being 3½ ft. lower than in the former. It is proposed to raise the water in the new aqueduct 1½ ft. above its present hydraulic grade, thus bringing it about 9 in. above the intrados of the crown at Jerome Park, and under these conditions the aqueduct will deliver about 310,000,000 gal. per day.

The water to be delivered through the old aqueduct, 90,000,000 gal. per day, will be lifted 5 ft. to deliver it to the filters. The water from the aqueducts will enter the west basin of the Jerome Park reservoir, the high water line of which will be kept at an elevation of about 133, and will be supplied to the filters through a distribution chamber from which it will flow to the settling basin over a weir about 600 ft. long, thus making a very even distribution of water into the settling basin.

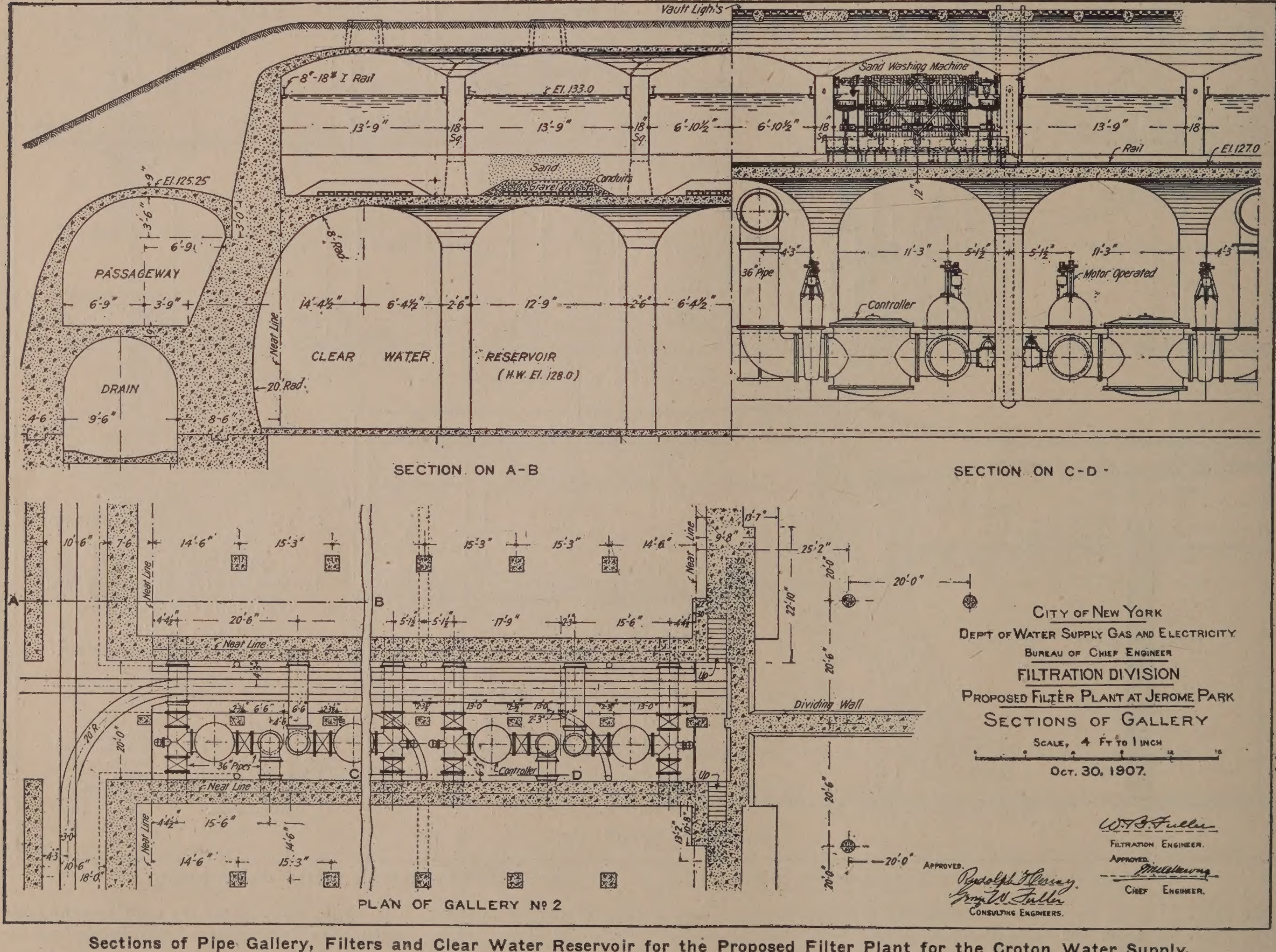
The method of delivery through both aqueducts, as above stated, has been adopted not only to facilitate the design of the filter plant, but to secure the great additional advantage of allowing, when necessary, bringing the whole Croton supply, even at its maximum, after the watershed has been fully developed, through the new aqueduct, and to use the old aqueduct for whatever additional supply may be temporarily furnished from up the State before the completion of those works. The importance of this feature will be readily appreciated.

Under the proposed plan, the high water line on the clear water basin will be at an elevation of 128, so that 325,000,000 gal, of filtered water can be delivered at the Central Park reservoir with the latter full, and 75,000,000 gal. more through pipes already partly laid or about to be laid, without reducing the pressure either south of the Harlem River or in The Bronx.

Whenever it may be necessary to use a coagulant for the reduction of color, it will be added just before the water enters the distributing chamber.

The settling basin has a capacity equivalent to about 18 hours' flow and is divided into five compartments, any one of which can be shut and independently cleaned. The basin is about 1,200 ft. long and the velocity of water is only from

10 to 20 in. per minute. At the southern end of the settling basin the water passes over a gathering weir and enters a raw water distributing conduit extending 1,200 ft. long across the entire end of the filters. This water is allowed to enter the filters by means of sluice gates connecting directly with the filter space above the sand. There is no raw water piping of any description and the opening of these gates floods the entire 42 acres of filter plant above the surface of the sand, which will therefore present the appearance of a large pond. The filters are placed on groined arches above the clear water reservoir and are built of concrete, each filter being 0.4 acre in area and consisting of three bays, each 410 ft. long. The filter medium consists of 25 in. of sand supported by 9 in. of graded gravel, which, in its turn, is supported by a system of tile underdrains leading to the pipe gallery. The pipe gallery consists of a dry tunnel dividing the clear water reservoir, in which are placed the controllers for regulating the rate of filtration.



Sections of Pipe Gallery, Filters and Clear Water Reservoir for the Proposed Filter Plant for the Croton Water Supply.

Above this tunnel the gallery will be flooded with water, and this portion may be used for transferring the washing machines from one bed to another, if it is decided to clean the beds with the machines. If the Brooklyn method of cleaning is adopted, the apparatus required will be floated along the transfer gallery to the beds, as required.

The clear water reservoir occupies about 46 acres at the southern end of the plant and is covered with groined arches. It has a capacity of 575,000,000 gal., including the basin under the filters, and the total storage capacity of the compensating basin, settling basin, filters and clear water basin is 1,785,000,000 gal. Advantage is taken of the two conduits in the present dividing wall of the reservoir to circulate the filtered water from the different divisions of the clear water reservoir, and also to bypass any of the clear water reservoirs if it is necessary to do so. These conduits convey the filtered water to a gate house, whence it is distributed to the city. The filters will be supplied with lines of rails on which a machine may be run, if desired, for the purpose of washing the sand, and each filter has also been designed so that the beds may be cleaned by the Brooklyn system, discharging into a drain connected with the city sewers.

At the end of one gallery there will be a distributing gate house and above this a chemical and bacteriological laboratory for the proper regulation of the plant. At the end of the other gallery there will be a machine shop for repairs to the mechanical equipment of the plant.

It is not proposed to cover the Central Park reservoirs, the use of which at present, Mr. de Varona states, causes a loss of pressure, because they will be abandoned for regular use when the Hillview reservoir is completed, and until then pipes can be laid from the Jerome Park reservoir sufficient to provide for the distribution for considerable less money than it would cost to cover the Central Park reservoirs, and these pipe lines will always be needed for the general distribution system. It is not proposed to cover the west basin of the Jerome Park reservoir, but to use it as a compensating reservoir, allowing the unfiltered water from the aqueducts to enter and circulate in this west basin before it enters the settling basin and filters.

The cost of the filter plant and covering of the reservoirs has been computed from detailed drawings at $7,600,000, which was the figure given in Mr. de Varona's previous report. In order to provide, however, a liberal allowance for contingencies, he deems it advisable to add about 12 per cent. to the above figures, making the total estimated cost $8,500,000.

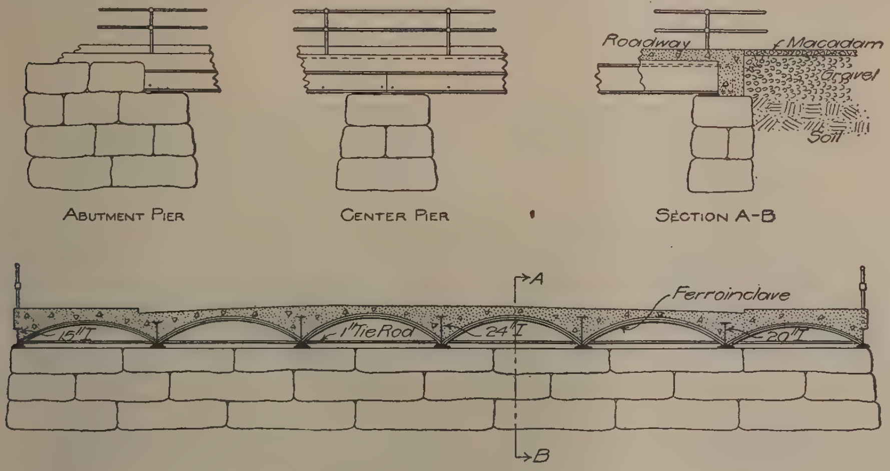
The cost of maintenance has been estimated at $2.50 per million gallons, including expenses of operation, administration, laboratory, care of grounds, lighting, repair gangs and depreciation, but exclusive of interest and sinking fund charges.

Grade Change on the Canadian Pacific Railway.

The Canadian Pacific Ry. is building a new stretch of track on the west side of the summit of the Rocky Mountains, between Hector and Field. The present line is on a 4.4 per cent. grade and has a maximum curvature of 12 deg. Four miles of this track will be abandoned when the new line, 8¼ miles long, is completed. The new alignment has a maximum grade of 2.2 per cent., compensated, and a maximum curvature of 10 deg. The features of the new work are two loop tunnels, both on 10-deg. curves, and a 1.6 per cent. grade. One of them is 2,800 ft. and the other 3,200 ft. long. In each case, according to "The Canadian Engineer," the upper line crosses the lower immediately above the portal of the lower entrance to the tunnel, thereby doing away with an overhead bridge crossing. The rock excavation will be 400,000 cu. yd.

A Simple Highway Bridge.

The details of a very simple type of highway bridge recently constructed at Fort Plain, N. Y., are shown in the accompanying illustrations. There are two spans in this bridge, each of about 20 ft. These consist of I-beam stringers having curved Ferroinclave sheets sprung between their lower flanges. On top of the sheets was placed a mixture of 1 part of Portland cement to 2 parts of sand to a thickness of about ½ in. above the tops of the corrugations of the sheet, and then concrete mixed 1:2½:5 was laid to the required depth. After the concrete on the upper side had been put in place, the Ferroinclave was coated on the under side to a thickness of ⅜ in. with a mixture of 1 part of Portland cement, 3 parts of sand and half a part of hydrated lime. It will be seen that this type of construction is substantially that used for arched floors. The advantage of it for this particular bridge was that the work could be easily and quickly erected without the use of any centering, the Ferroinclave sheets themselves acting as centering. In order to drain the roadway, the slope was taken care of by increasing the thickness of the concrete upon the upper side and, in the gutters, pipes were run through the Ferroinclave sheets on either side at fixed intervals and the concrete on the upper side was placed around them, thus giving down spouts through the bridge itself. The bridge was built by the Brown Hoisting Machinery Co., Cleveland, Ohio.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SECTION A-B

A Simple Highway Bridge.

The Iron Ore Resources of the United States.

The iron ore resources of the United States are discussed in a report by Mr. E. C. Eckel, of the U. S. Geological Survey, which states that the Lake Superior District is assumed to have from 1,500,000,000 to 2,000,000,000 tons, and that this supply is being drawn upon at a rate which will pretty well exhaust it by 1950. The workable iron-ore reserves above the 1,000-ft. level in Alabama, Georgia, Tennessee and Virginia are estimated to contain 1,850,000,000 tons of red ore and 725,000,000 tons of brown ore. Adding to these quantities the ores at deeper levels in the four States and also the red and brown ores which occur in Maryland, West Virginia and Kentucky, and the magnetic ores of the other Southern States, it is considered probable that the total Southern ore reserve will amount to very nearly 10,000,000,000 tons, or about five times that credited to Lake Superior. These figures are issued to disprove the widely quoted assertion made in Sweden to the effect that the whole world has only 10,000,000,000 tons of iron ore which is yet unmined.

The Density of Pavements.

The importance of the density of a pavement as an influence on its durability was discussed in some detail by Mr. J. W. Howard in a paper read at the recent convention of the American Society of Municipal Improvements. It is particularly important, he pointed out, in all composition pavements, laid in monolithic or sheet form, such as asphalt and bitulithic. That which is densest is to be preferred, he stated, as is shown by the fact that the natural bituminous limestone or rock-asphalt pavement of Europe is denser, closer-grained and more durable than many, but not all, of the artificial asphaltic sandstones which are the principal asphalt pavements laid in American cities.

Density and consequent longer durability reduce the cost of maintenance, which in the end is the greatest cost because maintenance goes on forever. Asphalt mixture pavements, composed of sand, limestone dust and asphalt cement, too often lack density and are porous, according to Mr. Howard. In such cases they do not resist traffic nor weather as well as if they had the maximum density possible with proper mixture and compression. The bitulithic pavement he considers an example of concentration of as much mass as possible into a given space. It aims to assemble crushed stone so that there is a minimum of voids and it approximates the original solid stone from which the crushed stone is obtained. The density of the composition of bitulithic pavements combined with the density of hard stone used he considers as probably the principal reason for the degree of success which that special pavement has attained.

The same reasoning Mr. Howard applies to all other kinds of pavements, different bricks, different woods, and the like proposed for paving streets. Each kind of pavement, granite block, bitulithic, asphalt, and the others, is suited to certain kinds, locations and characters of streets. The knowledge of the comparative densities of these different materials, shown by tests in definite figures, helps determine what kind of pavement to use for individual streets and further helps determine which one of many granites, bricks and composition pavements offered is best for use in each case. Requirements of minimum density for each kind of pavement should be inserted in all specifications, he asserts, in order to help secure, in conjunction with other and usual requirements, the best possible pavements.

Two types of density are discussed by Mr. Howard. The first is the density of the pavement, including its voids, which he regards as the most important because it is of the actual pavement laid. It is the weight per unit volume of the given material, and can be expressed in pounds or as specific gravity of the pavement, dried before testing and with air but no moisture in the voids of the specimen. This density may be called volume-weight. The second density is the specific gravity of the materials of which the pavement is composed, exclusive of any voids present in the pavement.

To illustrate the two densities, one of the finished pavement and the other of the material, entering into the pavement, Mr. Howard mentioned certain Baltimore bitulithic pavement made of crushed stone so graded in sizes and assembled by mixing that a very small percentage of the volume is unfilled voids. He found a specific gravity of a large piece cut from the pavement to be 2.69, whereas the solid stone of the same kind as the crushed stone in that pavement had a specific gravity of 2.96. The pavement has about 9 per cent. less density than the stone which is its principal element. The first is the specific gravity or density of the pavement as laid, the second is the specific gravity of the stone used in that pavement. The asphalt pavements of the United States, as laid, vary in density as specific gravity between about 1.90 to 2.24, whereas the density of their main elements, sand and limestone dust, exclusive of voids, is between about 2.60 and 2.70. These pavements are therefore 15 to 25 per cent. less dense than their principal mineral elements. The requirement in specifications for some wood pavements, that the blocks when dry must at once sink in water, is a crude way of requiring that the wood must have a certain degree of density. It is better to express this by definite figures.

Valuable deductions at once follow, Mr. Howard says, from knowing the volume-weight of the pavement, including voids, and the density of its materials excluding voids. The density-grade (or percentage of density) and the void-grade (or percentage of voids) of a pavement can be found. The density-grade d is obtained by dividing the volume-weight w of a pavement by the density or specific gravity s of the materials of a pavement. This is the percentage of the pavement which is solid mineral matter which should be as large as possible. The void-grade v, obtained by subtracting the density grade from unity, which is the percentage of voids in the pavement, which should be as small as possible. For example, in the Baltimore bitulithic pavement referred to, $w = 2.69$, $s = 2.96$, $d = 91$ per cent., which density grade means that 91 per cent. of the pavement is solid stone, and $1 - d = v = 9$ per cent., which void-grade means that 9 per cent. of voids exist between the broken stone, which volume or space is filled with fine dust and bituminous cement. Asphalt, brick, wood and other pavements can have their density-grades and void-grades determined in the same manner.

MOISTURE in the University and Municipal Libraries at Ghent, Belgium, was so great that some parts were entirely abandoned, but it seems probable, according to U. S. Consul W. P. Atwell, of that city, that a new method of drawing humidity from walls (which he does not describe in his report on the subject) will make these rooms serviceable. The official experiments began July 14 and were completed Aug. 14. The hygrometrical degree of the air in the room, of approximately 1,200 cubic meters, where the different experiments took place, was 83° on July 13. At that time a strong moldy smell was found to exist. The greater part of the wall was covered with saltpeter, while the floor or pavement was almost continually wet. On Sept. 13, after testing the new system thirty days, the hygrometer was found to have lowered from 83° to 60°. The walls had become completely dry, and the saltpeter and smell had disappeared. The pavement was dry and remained so, while prior to these experiments it had always been moist.

Lowering a Large Pneumatic Caisson with Screw Rods.

The west river pier for the four-track Schuylkill River Bridge of the Philadelphia Rapid Transit Co. was built with a 20 x 80-ft. wooden pneumatic caisson, sunk 40 ft. to rock through water 16 ft. deep and a mud and silt bottom. On account of obstructions in the river and the long distance in which it would be necessary to tow it, it was considered undesirable to build the caisson in the usual manner on shore and launch and float it to position, and arrangements were made for constructing it vertically above its required position and lowering it to place under control.

As its location is adjacent and nearly parallel to the city bulkhead wall, the latter was utilized for a portion of its support and carried part of the working platform, on which materials were received and stored and part of the work was done. A pile platform about 42 ft. wide and 127 ft. long was built parallel to the bulkhead wall and about 58 ft. in the clear from it. This consisted of 17 transverse bents of four and six piles each, which were capped with transverse timbers and supported a deck of 4-in. plank.

The space between the platforms was bridged by 12 x 12-in. timbers, on which a working platform was placed, and the wooden caisson was built to a height of 10 ft., including the deck, and was calked and completely finished. Six heavy forged steel flat hooks were then attached to the cutting edge equidistantly on each side of the caisson, and their upper ends were pin-connected to vertical 2½-in. rods about 24 ft. long, close to the outer face of the caisson. The rods were threaded full length and fitted with nuts engaging steel bearing plates on the tops of 12 x 12-in. timbers about 3 ft. long, through which the rods passed with clearance. These timbers were seated transversely on the top flanges of pairs of 20-in. I-beams, 30 ft long, supported at each end, just beyond the vertical rods which passed between them, on four lines of longitudinal 20-in. I-beams, supported close to each side of the caisson by six timber cribs up to a height of about 7 ft. above the deck of the working platform.

Lowering Pneumatic Caisson for West Pier.

East Pier Caisson Suspended from Girders.

Scaffold planks parallel to the caisson were seated on the lower flanges of the transverse I-beams, making working platforms for pairs of men, with 6-ft. wrenches, who first turned up the nuts on the long vertical rods sufficiently to raise the caisson, which had an estimated weight of 180 tons, and released the 12-in. transverse bridge girders on which it had been erected. These were removed, and then the men, working simultaneously by signal, slacked off the nuts, one revolution, or ½ in., at a time, until in about 12 hours the caisson was lowered 16 ft. In this position the south end of the caisson rested on timber cribbing in the foundation of an old pier of the wooden bridge formerly occupying this site. The caisson was sufficiently embedded in the mud at this end to permit the application of air pressure, which enabled men to enter and cut away the obstructions under the cutting edge, while the other end of the caisson was suspended about 10 ft. above the bottom. After the obstructions were cut away the nuts were slacked still farther, until the screws were relieved of all stress, and their connected hooks were lowered free of the cutting edge and disengaged from it, after which hooks, rods, I-beams and cribbing were all removed, and the caisson was sunk through soft material to rock by the usual methods. To facilitate handling the heavy wrenches a line was tied to each near the head and made fast to the screw 2 or 3 ft. above it. This safeguarded the wrench from being dropped and was of material assistance in carrying its considerable weight every time that it was released from the nut and moved back and turned for a fresh grip.

The caisson for the east river pier of the same bridge was built nearly one year later in substantially the same manner as above described, and was then towed to the site and sunk in the usual way between guide piles. After this caisson was completed on its movable transverse girders it was suspended much as already described from overhead transverse I-beams, which in this case were seated directly on top of the cribs, without intervening longitudinal girders. This caisson weighed about 180 tons and was lowered about 12 ft. in 10 hours by a force of 36 men.

The piers were designed and built under the direction of the engineering department of the Philadelphia Rapid Transit Co., Mr. W. S. Twining, chief engineer, and Mr. Chas. M. Mills, principal assistant engineer. The work was executed by John Monks & Sons, New York.

An Elliptical Dome, 119 ft. on the major axis and 80 ft. on the shorter axis, was built about 1729 for the Church of Madonna di Vico at Vicoforte in Piedmont. Its existence was forgotten by architects until it was brought to their attention by an American traveler, Mr. L. M. Rossi. He was so charmed with this unusual edifice that he has written a book concerning it which the Macmillan Co. has recently published.

Tests of Track on the Pennsylvania Railroad.

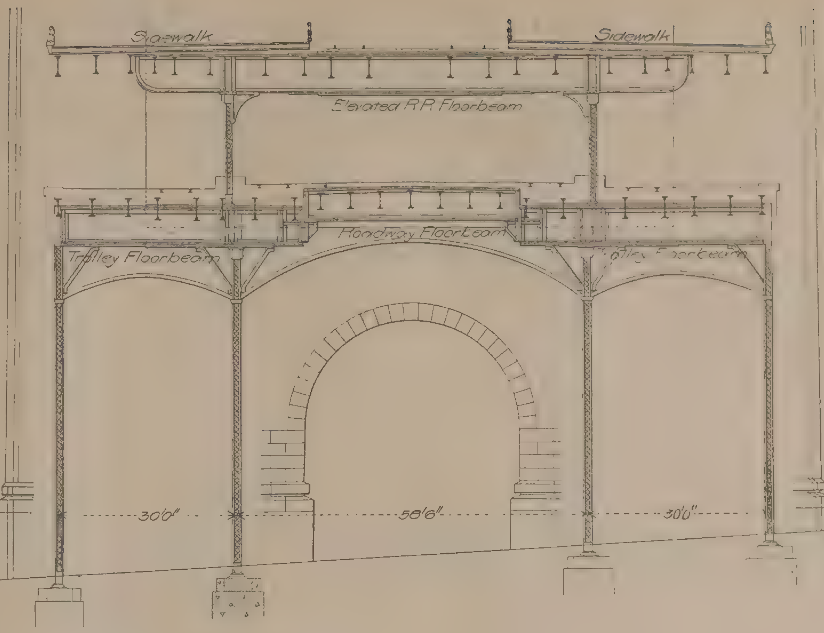
Reports which have recently appeared concerning certain tests the Pennsylvania R. R. has been making on the West Jersey & Sea Shore R. R., near Clayton, N. J., have created an entirely erroneous impression. It has been stated that the company was racing steam and electric locomotives, with a view to determining the speed capacity of each type. The Pennsylvania R. R. has other, more accurate and much less dangerous, methods of testing the speed of locomotives than trying them out in such a manner as this. Furthermore the types of electric and steam locomotives which have been used in these experiments were not designed for speed.

What the company is doing is this: Experience indicates that the operation of electric locomotives, owing to their lower center of gravity, has an effect upon the track different from that due to the action of steam engines. In order to ascertain the exact nature and extent of this pressure upon the rails the Motive Power Department has devised the apparatus which is being utilized at Clayton. A stretch of track about 166 ft. in length has been equipped with rails and cast steel ties, designed and made especially for this purpose. Instead of attaching the rail to the ties by spikes, a special form of block has been substituted which allows a slight movement of the rail as the engine goes over it. This movement registers the force with which the flanges of the wheels strike or press against the rails.

It is expected that a large number of experiments with this apparatus will show the company quite accurately what the effect is of either steam or different types of electric locomotives, moving at different speeds over either straight or curved track. Necessarily, to make these tests, the engines must move at different speeds. An electric apparatus has been devised to measure the precise amount of time elapsing while the different locomotives pass over this 166 feet of track, in order that in computing the effect upon the track the exact speed attained may be known. The steam and electric locomotives, however, go over the track at different times, and there is no element of contest as to speed between the two types. The matter of speed is purely incidental to the main purpose of the tests, which is to enable the company, in planning its electric installations in New York, to design a track so safe as to be absolutely secure against any form of locomotive that may be utilized.

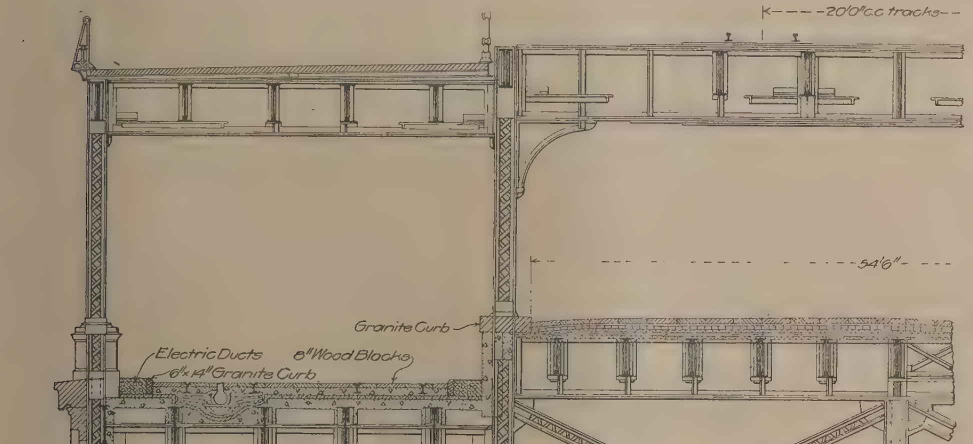
The Manhattan Approach of the Blackwell's Island Bridge.

The five main spans of the Blackwell's Island Bridge have a combined length of 3,724½ ft., a width over all of 86 ft., and a minimum height for a portion of each channel span of 135 ft. above mean high tide. They have, as described in various articles published from time to time in The Engineering Record, two lines of massive pin-connected trusses, 60 ft. apart, on centers which carry two decks, 15 ft. apart in the clear. The full-width upper deck provides for two elevated railroad tracks and two sidewalks, and is proportioned to eventually receive two more railroad tracks if necessary. The lower deck, 86 ft. wide, provides between the trusses for two Queens trolley tracks and a 36-ft. roadway. Outside of the trusses the symmetrical cantilever extensions are each proportioned to carry a single line of Metropolitan street car tracks.



Bent Adjacent to Anchor Pier.

The approaches are massive steel viaducts, connecting the shore ends of the anchor spans with the city streets at grade. They are built on tangents coinciding with the center line of the main span and provide for the same arrangements of decks and tracks, except as necessarily modified by the change of grade. They are, however, made considerably wider than the main spans, and although in the main conforming to standard high-grade bridge work, they are of somewhat unusual design and present features of interest, due to the efforts made to give them a monumental and artistic appearance, under difficult conditions and numerous imperative requirements that necessitated somewhat elaborate construction.



Typical Transverse Half Sectional Elevation of Viaduct.

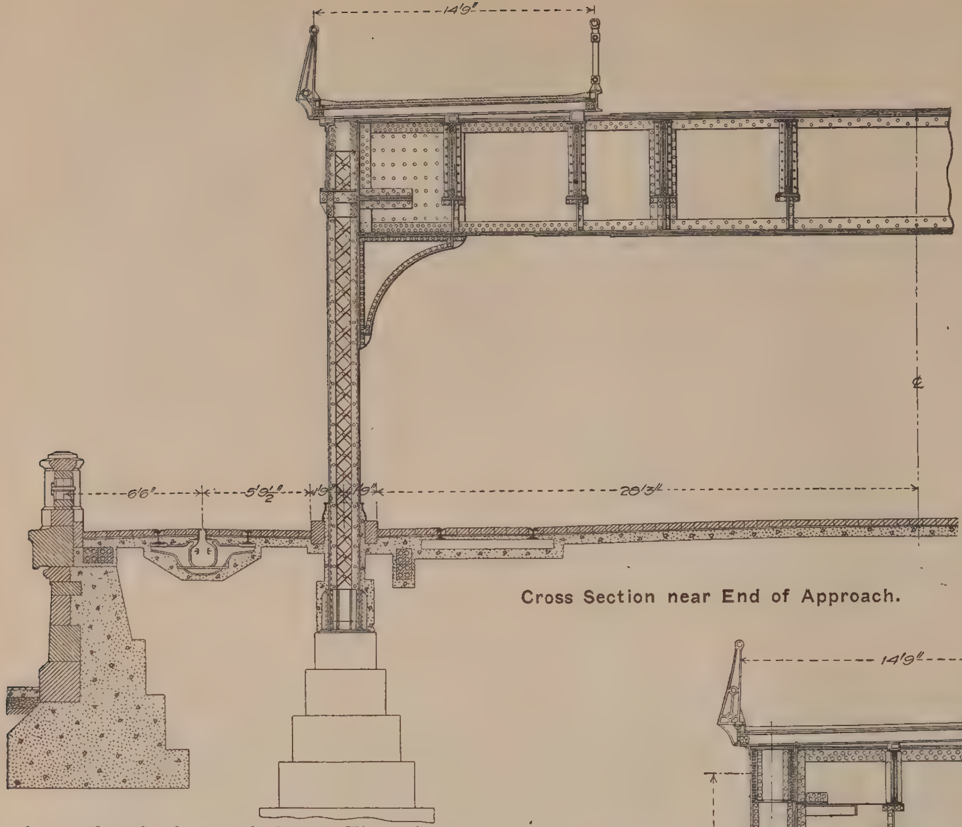
The Manhattan and Queens approaches are of very different character and construction, the former having a much more massive appearance and architectural treatment. It extends from a point between Avenue A and First avenue to Second avenue, two long city blocks, and occupies an area of about 1,070 x 230 ft. between curb lines. At Second avenue the main entrance occupies nearly the full width of this area, but the approach is soon reduced to a width of 120 ft., which is maintained up to the anchor pier, leaving spaces of about 90 ft. and 20 ft. on each side, which are paved up to the curb lines.

From the anchor pier, where the roadway is about 60 ft. above the level of the ground, the main deck is carried westward for 600 ft. on a steel plate girder viaduct, with 29-ft. spans, to a point where its height is only about 30 ft., and beyond which it is on a solid fill. Where it crosses First avenue a clear opening of 90 ft. is provided by a steel arch span, which carries the viaduct columns and is supported on massive masonry abutments. All of the steel work up to the lower deck is enclosed in granite and terra cotta, giving it the effect of stone masonry treated to represent slender arches between the bents of the steel work.

Each transverse bent has five vertical columns about 30 ft. apart, thus giving approximately equal spans for the longitudinal and transverse girders and dividing the horizontal plan into approximately square panels. Each of these panels is roofed about 25 ft. above the ground, with a waterproofed timbrel arch, which forms a false ceiling several feet below the solid roadway of the main deck, and provides underneath the viaduct an attractive sheltered space suitable for market and storage purposes.

The sidewalks are carried at the same grade as the roadway for a distance of about 100 ft. from the entrance, beyond which the grade increases, and they are carried by inclined longitudinal stringers, which gradually rise to the grade of the elevated structure at the anchor pier. The elevated railroad tracks from Second avenue are carried by inclined longitudinal stringers, which gradually rise to the grade of the elevated structure at the anchor pier.

The elevated railroad tracks from Second avenue are carried the full length of the approach on the second platform, which amounts to a plate girder viaduct, about 21 ft. high and 60 ft. wide, with 29-ft. spans. Each bent has two vertical columns 58.5 ft. apart on centers, which are seated directly on the tops of the intermediate



Cross Section near End of Approach.

columns for the lower platform. The columns are continuous with those of the lower viaduct, but above the main floor are not enclosed in masonry, thus frankly revealing the steel construction and giving the effect of a light superstructure on a massive substructure.

The two outer tracks on the lower deck of the approach diverge from the center line of the bridge at a point about 300 ft. from the entrance and connect by reversed curves with the surface tracks in 59th street and 60th street, which are about 260 ft. apart. Adjacent to them on the lower decks are two more tracks for the Queens trolley cars, which toward the entrance descend below the roadway level to a subway station occupying a trapezoidal area 300 ft. long and 200 ft. in extreme width below the surface of the ground.

In the subway there are five loops, allowing for continuous car movements, with opportunity for safely and rapidly loading and unloading. In each of the spaces between loops double transverse stairways descend from the main platform to the subway station between tracks, thus giving access to all of the cars without the necessity of crossing the tracks. This station is designed to be eventually connected with the proposed subway line. The roof is supported on transverse I-beams and longitudinal plate girders, carried by riveted steel columns about 20 ft. apart and covered with vault lights and concrete slabs.

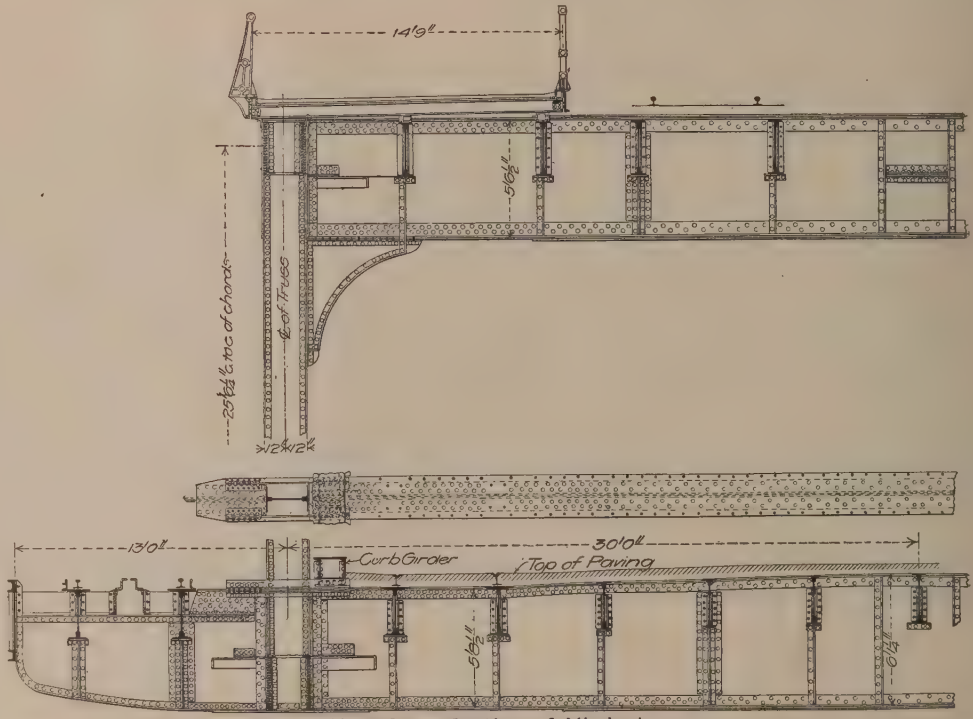
The transverse bents of the viaduct are sway-braced by solid-web knee-brace brackets under both ends of the elevated railroad girders, by detached knee-braces under both ends of the outer transverse girders in the lower deck, and by two panels of X-bracing between the three center columns below the roadway. Longitudinal bracing is provided by the main stringers and by wall girders connecting the outside columns and supporting the masonry between the tops of the arches and the parapet.

The wall girders consist of two pairs of angles from 3 to 13 ft. apart, and the space between them is divided into panels by vertical members and X-braced by single diagonal angles, besides which longitudinal knee-braces are run from the center of each panel to each column. The wall girders are made with pairs of 6 x 6-in. angles for the top and bottom flanges and for the web members, which are either zigzag or X-braces, according to the depth of the girder. Connection plates are riveted between the vertical legs of the flange angles to receive the members and project across the cover plates of the main columns, to which they are field riveted. The knee-braces have I-shaped cross sections, made with pairs of 4 x 3-in. angles, back to back, latticed.

The main columns have H-shaped cross sections, made with two built channels, latticed and connected by a center diaphragm. The center column extends to the lower deck only, and the four outer columns extend to the upper deck and are spliced just above the lower deck. Where they pierce the granite coping above the lower deck they are enclosed in a 4 x 2½-in. brass base, below which the interior of the column is filled with concrete. Except in three bents nearest the anchorage, all of the transverse girders are web-connected to the columns.

The longitudinal girders are spaced from 3 to 5 ft. apart under the sidewalks and roadway, besides one for each rail of each track. The roadway stringers support an 8-in. flat concrete slab, reinforced with transverse steel bars of 0.28 sq. in. cross sections, 6 in. apart, and longitudinal steel bars, 0.10 sq. in. cross section, 1 ft. apart, every alternate transverse bar being bent over the top flanges of the stringers. The upper surface of the concrete is covered with a ½-in. thickness of waterproofing, protected by a single course of red brick laid flat. On the bricks there is a 1-in. layer of cement mortar, in which the 4-in. creosoted wood paving blocks are laid.

The four transverse bents nearest the anchor pier are special and differ from the regular bents in the number and location of the columns and in the arrangement of the girders. Bent No. 1 is so near the anchorage that the sidewalk stringers can readily span from the anchorage to bent No. 2, and the regular transverse sidewalk girders are omitted, and the elevated railroad girders are made longer than the distance between their columns, so as to overhang them at each end. The center column supporting the lower deck is also omitted, and the two transverse girders in the outside panals are cantilevered 11 ft. beyond the interior columns, with notched seats on their ends to carry the extremities of a connecting center girder 26 ft. long.



Half Cross Section of Viaduct.

Bent No. 2 differs from the typical bent chiefly in that it has an arrangement of cantilever transverse girders in the lower deck similar to that in bent No. 1, and that two auxiliary columns, making seven in all, are located under the extremities of the cantilever girders. Bent No. 3 resembles bent No. 2, except that the auxiliary columns are omitted. In bent 2 and 3 the intermediate upper columns supporting the upper deck are eccentric from the corresponding one supporting the lower deck.

In the regular bents the elevated railroad transverse girders, 58 ft. 6 in. long, have webs varying from 48 x ⅝ in. to 66 x ½ in., with 6 x 8 x ¾-in. flange angles, and three 18-in. cover plates of varying length and from 9-16 to ¾ in. thick. They are seated on solid-web knee-braces about 6 ft. deep, which give very rigid connections to the columns and provide for swaybracing without diagonals.

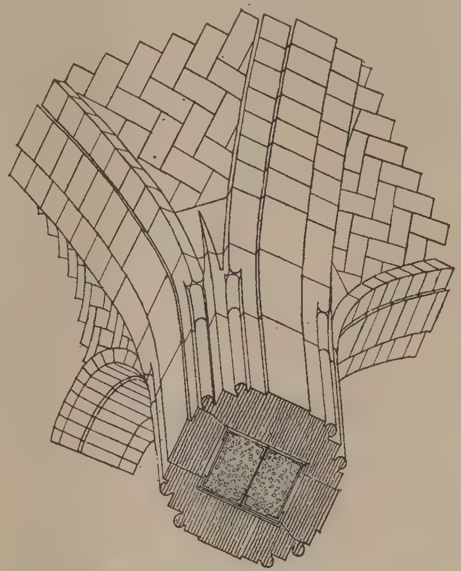
The side girders of the supper deck are 30 ft. long on centers of columns, have a 48 x ⅜-in. web plate, and in each flange two 6 x 6 x 9-16-in. angles and a 14 x ½-in. cover plate 22 ft. long. The ends are not knee-braced, but are seated on reinforced shelf angles and are thoroughly web-connected to the columns. The girders directly under these correspond to them, except in their dimensions, and that they have at each end a knee-brace made with a pair of 6 x 6-in. bent angles, riveted together back to back. They are 60 in. deep and have two cover plates.

The center transverse girder in the lower deck differs from the last described principally in having a single cover plate, and that it is made in two lengths, abutting in the axis of the bridge on top of the center column. There are also solid-web knee-brace brackets under both ends, which also serve as connections for the sway brace diagonals below the girder. The fixed ends of all longitudinal stringers are web-connected to the transverse girders.

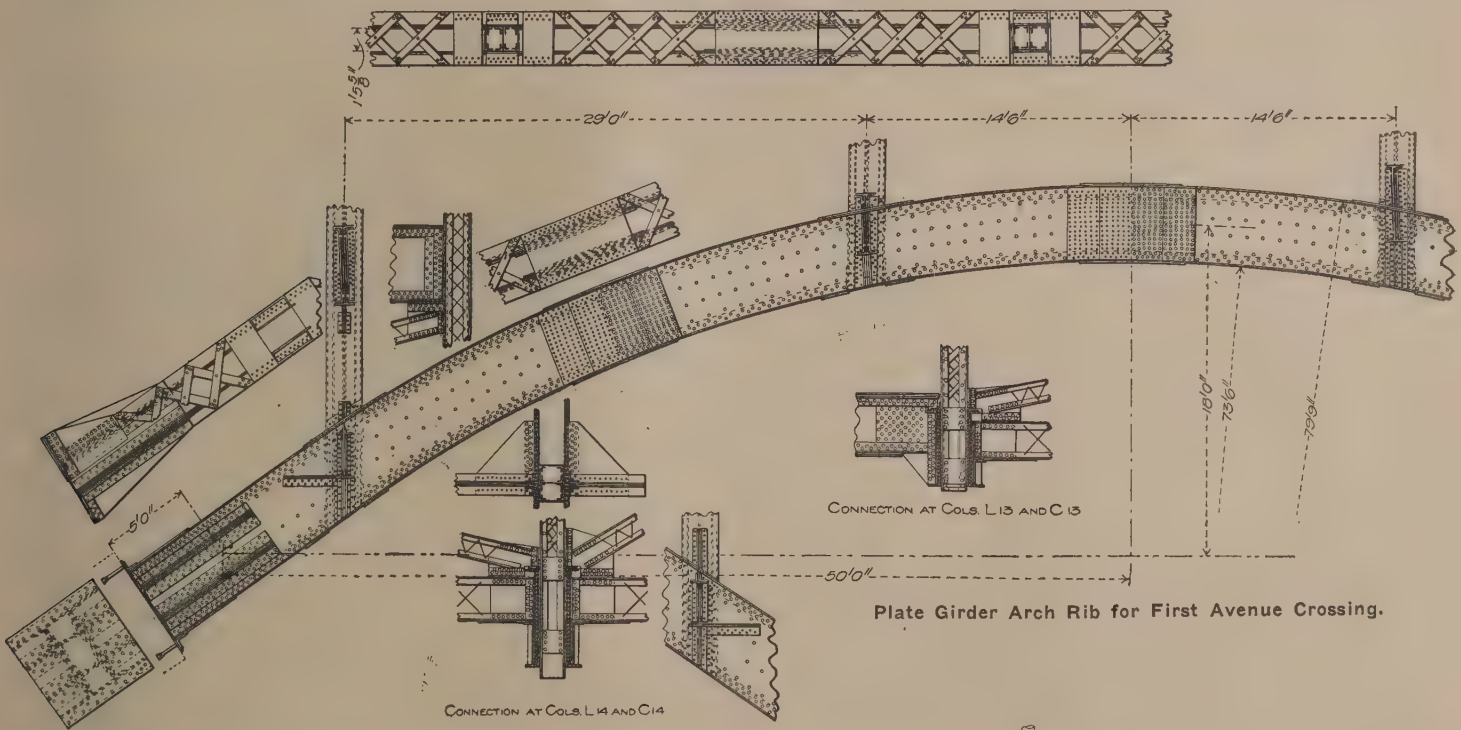
The expansion ends of the roadway stringers are seated in pockets projecting from the face of the transverse girder webs and have their lower flanges supported by and are free to slide upon a horizontal bearing provided by the outstanding legs of reinforced shelf angles. Short angles are riveted to the under side of the top flange angles at the ends, with their outstanding vertical legs engaging the faces of the pocket angles, so as to provide sliding bearings and hold the girder firmly in transverse position.

The expansion connection of the elevated railroad stringers is the same as that already described, except that the seat in the lower part of the pocket is made with a curved stirrup plate riveted to the pocket angles and receiving a convex cast shoe, on which the bottom flange of the stringer rests.

The stringers in the outside panels of the lower deck are made with drop ends seated on the top flanges of the transverse girders, so that the stringer flanges are elevated sufficiently above the girders to give clearance for the yokes of the electric conduits between them. The expansion girders slide freely on the top flanges of the transverse girders and on horizontal bracket angles riveted to the web of the girder to engage lower flange connection plates.



Column Enclosed in Terracotta.



Connection at Cols. L13 and C13

Connection at Cols. L14 and C14

Plate Girder Arch Rib for First Avenue Crossing.

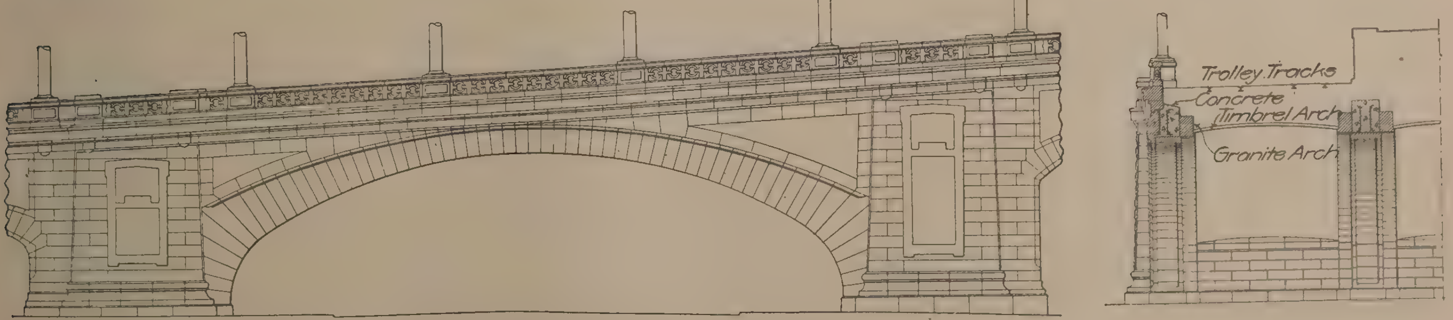


Plate Girder Arch over First Avenue.

In transverse bents 10 and 15, which form part of the tower at the extremity of the First avenue arch, there is X-bracing below the lower deck. No other bents have transverse bracing to the ground. The feet of the columns are reinforced with vertical transverse diaphragms, making H-shaped cross sections, with wide vertical flanged cover plates stiffening the extended horizontal base plate, which is also reinforced by 12 short vertical angles riveted to the webs of the channels and to their cover plates, with their lower ends milled to bearing on it and thus distributing the column load over the full area of the top of its pedestal. The pedestals are webbed steel castings, 12 in. high and 48 x 52 in. on the base.

The arch at First avenue is made with five hingeless box plate girder ribs, with a rise of 13 ft. and a span of 100 ft. on centers. Each end of the rib is produced 5 ft. beyond the extremity of the 100-ft. span line to reach the skewback bearings concealed in the interior of the tower and thus increases the real rise and span to about 16 ft. and 108 ft., respectively. Each rib is made with a pair of built channels 48 in. deep, with latticed top and bottom flanges and webs 16 in. apart. Each channel is made with one 48 x 11-16 in. and one 36 x 11-16 in. web plates and two 8 x 6 x 11-16-in. flange angles.

The two ribs which carry the elevated railroad columns have much heavier loads and are made with correspondingly increased dimensions and materials. Their nominal rise for the 100-ft. chord is increased to 18 ft., and each channel is built with two 48 x ⅝-in. and one 36 x ¾-in. web plates and two 8 x 6 x ¾-in. flange angles. In all ribs the ends are heavily reinforced by double pairs of angles, with filler plates between them riveted together back to back on the outer faces of the web.

The ends of all arch ribs are faced normal to the curve and have an extended base plate, anchor bolted to a cut stone pedestal. Each rib is shipped in four sections, with radial butt joints at the crown and quarter points, which are thoroughly spliced with field riveted web and flange cover plates. Each rib carries four vertical columns, with its flanges field riveted between the webs of the rib. The quarter splices will be riveted before any floor weight is imposed on the span, but the crown splices will not be riveted until most of the dead load is carried by the rib.

The spandrel walls carried by the arch ribs will be built with ¼-in. vertical joints at the end bents, filled at first with asbestos felt and afterwards pointed with lime mortar. Each rib is to be enclosed in a solid rectangular mass of concrete and will be faced on the two vertical sides with granite voussoirs, anchored to it and provided with skew-back bearings, so that they really form independent, self-supporting arches. Thin flat soffit pieces of granite are also anchored to the rib to connect the two side faces and cover the intrados. Projections on the lower part of the side voussoirs receive and support the ends of the timbrel arches, which connect the main ribs and form panels of a ceiling between them.

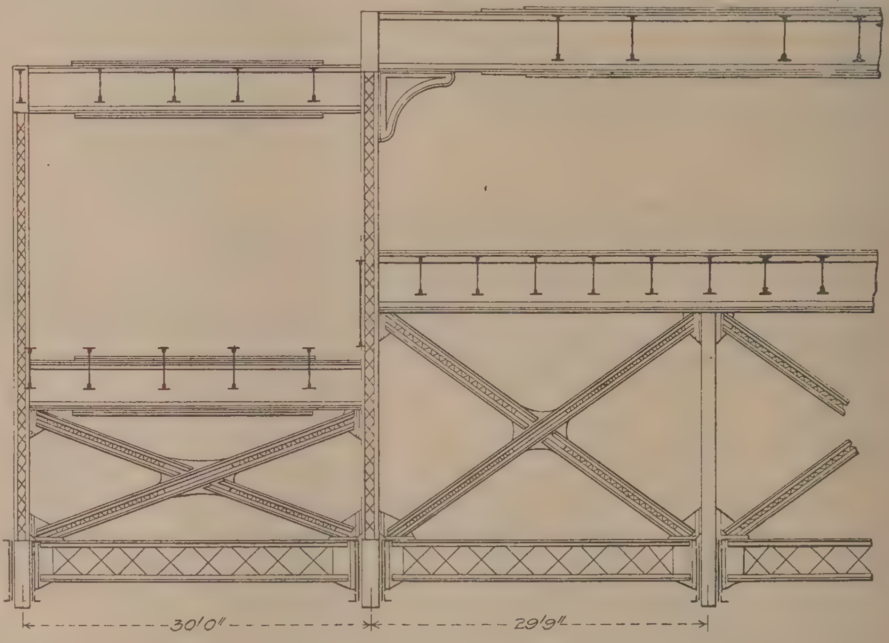
The lower portions of all columns are filled solid with concrete, and the columns are enclosed to the height of the timbrel arches with moulded terracotta blocks, which give them the appearance of cut-stone work, and are carried up to form skew-backs for the fascia arching and above them to divide the spandrel walls into panels, which between the arch and the parapet is filled in with ornamental tiles. The parapet is made with solid projecting courses, forming a cornice at floor level, and with ornanmental perforated courses, forming a massive balustrade.

The structure is proportioned for a maximum concentrated loading, and the specifications for material and workmanship of the different portions of the structure correspond in general to standard requirements. Concrete is made in three grades, namely, of 1:3:6 for the substructure, 1:2:4 for the upper part and 1:4:8 for cinder concrete as a filling under the floor. All concrete is machine mixed and thoroughly rammed and is made with Giant Portland cement, which in 40-ton or carload lots must show in the 28-day test average results 15 per cent. better than the 7-day tests for neat cement and 25 per cent. better than the 7-day test for 1:3 samples, besides developing the required minimum strength. All exposed granite work is finished with rock face, rough pointing, Pean hammering, or four cut. Rough pointed surfaces are uniform within ½ in.

All structural steel is made by the open-hearth process by either acid or basic methods, with the maximum percentages of phosphorous, sulphur, manganese and silicon limited to .06, —.04, —.06 and .10 per cent., respectively, for both, except for basic steel, which may not exceed .04 per cent. of phosphorous. All steel, except rivets, has an ultimate strength of 60,000 to 68,000 lb., elastic limit of 33,000 lb., elongation of 1,600,000, divided by the ultimate, and a minimum reduction of area at point of fracture of 44 per cent. Variations for weight are permitted, in accordance with the standard specifications of the American Society for Testing Materials. Rivet holes are drilled from the solid through materials more than ¾ in. thick and in other material are punched and reamed. All rivet holes are reamed with a special reamer making a 1-16-in. filet under each end of the rivet. All beam and stringer connections are reamed to cast-iron or steel templates ⅝ in. thick, with hardened bushings for all holes. Fluted reamers are not allowed. When hand rivets are unavoidable they must be driven entirely with 8-lb. hammers.

The concrete floor and roof slabs are waterproofed with hydrex felt or equal and coal tar pitch, which is also applied to the side walls of the subway stations. The concrete roadway and solid track floor are cast in position. The 1:2:4 reinforced concrete sidewalk slabs are cast in moulds in the contractor's yard and stored 30 days before using. They have a ½-in. wearing surface of 1:1½ Portland cement and sand, are laid on ½-in. mortar beds over the steel bearings and have ½-in. joints filled with 1:2 grout. Very complete specifications are given for the track construction conduits and electrical work. The principal quantities involved in the work include 35,000 cu. yd. of excavation, 6,000 cu. yd. of fill, 16,000 yd. of concrete, 110,000 cu. ft. of cut stone and 130,000 sq. ft. of terracotta. The estimated weight of the structural steel is about 12,000,000 lb.

The bridge was designed and its construction is being supervised by the Department of Bridges, of New York City, Mr. James W. Stevenson, Commissioner; Mr. C. M. Ingersoll, Jr., chief engineer. The contract was awarded May 21, 1907, to the Snare & Triest Co., Mr. Frank Miller, chief engineer, and Mr. J. C. Haine, resident engineer. The steel work is being fabricated at the Pennsylvania Steel Co.'s shop, and concrete is made with Giant Portland cement.



Half Transverse Section through Arch Span at Haunches, Blackwell's Island Bridge.

A Five-Span Bridge across the Rhine containing a center cantilever span of 678 ft., was completed during the present year. The bridge, which connects Homberg and Ruhrort, spans two canals, and a harbor basin, in addition to the river, and has a total length of 2085½ ft. The spans are 296¼ ft., 405¼ ft., 678 ft., 427½ ft. and 278¾ ft. The width is 54 ft., divided into two 8 ft. footwalks and a 38 ft. roadway carrying two electric railway tracks. The foundations, according to "The Engineer," London, proved a difficult task because of mines, which are still being worked, under the river, and their design was adapted so as to cause no danger to the workings. The cantilever arms are each 114 ft. long, and the suspended span, which is hung freely between them so as to expand and contract, is 450 ft. long. The total load coming on each of the two piers for the cantilever span is 9,194.6 tons, of which 1,782.8 tons is due to live load. The load on the foundations is about 11,800 lb., or 5.9 tons per square foot. The approach and anchor spans were built on wooden falsework. The cantilever span was built without obstructing the channel, except that a temporary timber pier was built in the center of the river to carry the suspended span during erection. The total cost of the structure, including piers, falsework and all expenses, was about $1,092,700.

Road Hardening and Dust Prevention about Boston.

At the regular quarterly meeting of the Massachusetts Highway Association on Nov. 12, road hardening and dust prevention were the topics considered. The first paper was read by Mr. John R. Rablin, engineer of the Metropolitan Park Commission, Boston. Mr. Rablin referred to the treatment with tarvia of 3½ miles of park roadway in Revere, Chelsea and Everett about a year ago, and stated that a test of this length of time, with attending severe winter conditions, enabled some judgment to be formed of the merits of the treatment. During the winter one portion of the roadway for a distance of about 2,000 ft. showed signs of scaling, the top surfacing of tar and screenings about ¼ in. in thickness breaking up and leaving the roadway in about the condition it was before treatment. This action he assumed was due primarily to the condition of the road on which the tarvia was placed, an excessive amount of binding material having been used in its construction, which prevented proper penetration. After the scaling the road remained in good condition, however, and seemed to derive some benefit from the treatment. One other section, 1,500 ft. long, appeared to have been lightly treated; that is, too little material was used, or it penetrated more rapidly or to a greater extent than ordinarily, as the larger stones of the road were not covered with the surfacing of tarvia and screenings. This road seemed thoroughly bonded and remained in good condition. Generally winter conditions had no bad effects, and the roadways have been clean and free from dust or mud.

In July, 1907, some other portions began to show the effects of wear, and during July and August about one-half of the 3½ miles treated in the fall of 1906, including the portion which scaled and the portion improperly treated, were re-treated with tarvia, and the balance of the 3½ miles patched where necessary. The average cost of the re-treatment was 6.4 cents per square yard. Considering the entire 3½ miles, the cost of maintenance of the tarvia surfacing, including re-treating and patching, was 3.5 cents per square yard.

During this year, about 90,000 sq. yd. of roadways have been treated with tarvia at an average cost of 7.3 cents, in addition to the maintenance of that laid in 1906. The cost of the different jobs varied from 5.8 to 9.3 cents, the variation being due principally to the condition of the roadways treated, the cost of labor varying the greatest amount, and the cost of tarvia varying somewhat with the amount required for the different conditions of roadway. Some portions of this new work became uneven and rough on account of the bunching of the tarvia, attributed to a variation in the quality supplied. This condition did not lessen the effectiveness of the treatment, and in general the results of the use of tarvia have been satisfactory, the road surfaces being preserved practically dustless and mudless.

Various experiments were made during the year by the Metropolitan Park Commission in the use of oil on the roads, notably in the Charles River and Revere Beach reservations. These roads were treated with a petroleum product called "asphaltoilene," which is furnished and applied by the Good Roads Improvement Co., of Cincinnati. This material is a Kentucky oil with the naphtha and other volatile substances removed, leaving a heavy asphalt base, which is applied to the surface of the road in its natural state by the White oiler, a machine used in oil applications in California. This treatment requires a road in particularly good condition, either nearly new or newly resurfaced, and very little cleaning except the removal of loose dust is necessary. The cost of this work was 6 cents per square yard for the material and its application. The cost of cleaning was negligible.

COST OF TARVIA TREATMENT, METROPOLITAN PARK COMMISSION.

Roadway.	Work Done, 1907.	Total Cost.	Sq. Yds. Treated.	Tar Used, Gals.	Stone Used, Tons.	Cost per Sq. Yard. Labor.	Tar.	Stone.	Total.	Tar per Sq. Yd.	Stone per Ton.
Middlesex Fells	Aug. 19-31	$1,403.74	15,000	8,846	234	$ .0318	$ .0383	$ .0234	$ .0935	.5897	.0156
Revere Beach Parkway	June 20-July 6	912.33	12,780	4,087	219.6	.0200	.0250	.0260	.0710	.3200	.0170
Revere Beach Parkway	July 6-Aug. 17	3,020.53	47,260	18,182	712	.0151	.0282	.0206	.0639	.3840	.0150
Winthrop Shore	Sept. 23-Oct. 12.	1,635.95	23,500	10,845	256	.0215	.0324	.0157	.0696	.4615.	0109
Lynnway and Northern Circle	Sept. 16-21	736.55	8,840	4,710	189.5	.0185	.0376	.0272	.0833	.5300	.0214
Revere Beach Reservation	May 22-June 22.	1,315.37	22,825	8,955	359	.0107	.0282	.0188	.0577	.4011	.0167
					Avg. cost.	$ .0196	$0.0316	$ .0219	$ .0731	.4477	.0161

The Charles River road is about 1 mile long and is constructed with a gravel surface. An excessive amount of oil was used here on account of the uneven condition of the road, necessitating a week's closing to allow proper penetration. A light sprinkling of gravel was required in some places to absorb the surplus oil. This road has been in excellent condition since the work was done in June, 1907, and has required no watering and no repairs. Although the appearance was not very agreeable at first it appears that the excess of oil will enable the treatment to last another year if the frost does not injure it to any great extent.

About 17,000 sq. yd. of the Revere Beach drive was treated with this material. This road is a macadam, had been constructed 1 year, and was in very good condition. Too little oil was used, especially at the sides, on account of a fear of marring the appearance of the concrete gutters and edgestones. Therefore the road was not thoroughly bonded, and early this fall began to pick up a little. Another light treatment was given it where necessary and it is now in very good condition. Mr. Rablin considered this treatment effective in preventing dust and in bonding the road surface, especially with a gravel surface. The oil gives no offensive odor. In the Middlesex Fells Reservation 140,000 sq. yd. were treated with a mixture of water-gas tar and Kentucky oil similar to that just described. At the beginning of this work an emulsion with 25 to 30 per cent. oil was used, but Supt. Price experimented with the mixture of oil and water-gas tar; considered it cheaper and fully as good, and used it for the greater part of the work. This mixture is made in proportions varying from two barrels of oil and six barrels tar, to four of oil and six of tar, depending on the road condition. This mixture was heated by a steam coil and applied by a special attachment to a watering cart designed by Mr. Price. This treatment thoroughly lays the dust, remaining effective eight to ten weeks, but after that time further treatment is necessary. The method has little, if any, bonding qualities and does not prevent the roads from being stripped of their surfacing, the materials working into the gutters. The average cost of one application is about 4 cents per square yard.

In the accompanying table cost data for *tarvia treatment* of roadways by the Metropolitan Park Commission are given in detail:

The cost to maintain the Revere Beach Parkway (8,880 sq. yd. new) was $2,377.25, 67,434 sq. yd. being treated. The cost per square yard was $0.0351.

Mr. Rablin stated that the net cost of oil per gallon was 7.5 cents, and tar 3.5 cents. One gallon of the oil mixture would take care of 3 sq. yd. of roadway, on the average. On the Revere Beach Parkway from 0.5 to 0.75 gallons of asphaltoilene per square yard were required.

Mr. F. C. Pillsbury, division engineer of the Massachusetts Highway Commission, pointed out that the effect of automobile travel has been so injurious on the through lines of main roads between Boston and interior points that if any one of these roads were to be macadamized new today and then subjected to the automobile traffic of the past season, it would be necessary to resurface it in about two years, even under ordinary repairs. The Highway Commission concludes for the present that tarviating is the best method for protecting the surface of macadam roads, consequently at Lynn, Weston, Wayland, and other points this process has been used.

At Lynn a road extends across the marshes, and is much exposed to sun, wind and high-speed automobile operation. The result was that one year from completion of about a mile of almost perfect road, the highway had to be resurfaced. A month later tarvia was applied. An unusual expense was incurred in the removal of a crust formed by the fine stone and dust swept to the sides by the automobiles, and used for binder in re-surfacing. It was rolled down with saltwater, and when the surface came to be cleaned about 0.5 in. of this crust was found, which had to be loosened with harrows and picks and taken up with shovels. The portion of the road on which the tar was coolest when used made the best surface. In order to allow use of the road it was tarviated half at a time, but the result was a patch at the overlap. Since July 4 the road has shown practically no signs of wear, though subjected to probably as much automobile travel as any road in Massachusetts. The only repairs necessary have been at a few small spots, the largest not over 2 ft. long, where all the crust of mud was not removed.

On the Wayland road it was necessary to first patch and re-surface the entire macadam and clean it, which ran up the cost. At Weston the surface was better. It was found at Wayland that by rolling clean sand into the No. 2 stone on the surface, only a little more tar was used than on an old hard road. This disproved the idea that one could not tarviate on a newly re-surfaced road. The tar was used on the clean, new stone without spreading stone dust and water. The result has been better on the newly re-surfaced places. A number of experiments with sand and stone screenings were made for a covering material, but the best results were obtained with pea stone. All fine dust and floury material should be excluded.

At Wayland, as an experiment, a mixture of pitch was tried in the proportion of one barrel of pitch to three of tar, and one to four also. There was no apparent difference in the applying nor as yet in the wear.

The U. S. Government, through the Good Roads branch of the Department of Agriculture, working with the Commission, conducted some experiments on the Wayland and Weston roads. Mr. Prevost Hubbard, a chemist, of Washington, was in charge. Tarvia, coal tar, water-gas tar, rosin, salt and terra-colio were tried singly and in mixtures. The terra-colio, an emulsion of a crude oil preparation, has done very well as a dust layer in two applications. There seems to be little choice between any of these; possibly the mixture of coal and water-gas tar with rosin and salt may have the best qualities for wearing surface and dust laying. The water-gas tar was also used alone. It was spread on the macadam from a tank car and then covered with fine gravel and rolled. At first the tar and sand mixture became loose in patches, but it gradually packed down and now presents a very good surface, giving practically no dust. Careful records of weather and temperature were kept in all this work. The following costs were obtained:

	Length.	Width.	Area.	Cost per Sq. Yd.	Tarvia per Sq. Yd.
Lynn	0.78 in.	31.4 ft.	14,480 sq. yd.	$0.087	0.44 gal.
Weston	3.15 in.	15.0 ft.	27,720 sq. yd.	0.12	0.55 gal.
Wayland	2.25 in.	13.0 ft.	18,286 sq. yd.	0.215	0.55 gal. resurf.

The tarvia work at Wayland cost about 8 cents per square yard. At Lynn the road was near the coal tar company's base of supplies. The Commission used two heating kettles, heating four or five barrels of tar at once. An average of 1,000 lin. ft. or 2,000 sq. yd. a day with one gang was about the best that could be done in fair, dry weather. Mr. Pillsbury advocated the use of larger kettles, regular machines for heating and spreading the tar, as in France; cleaner sweeping, perhaps with a vacuum cleaner; securing uniformity of tar by test and inspection, and not beginning work before May 1 or continuing it after Oct. 1. He stated that the Warren Brothers bitulithic pavement seems to stand the wear of automobiles best, but at too high a cost. He doubted the permanence of a coating of tar on state highways, and suggested increasing the depth of the tar surfacing, either by forcing it farther into the stone when the roads are first built, by using compressed air, or by increasing the thickness on the top. Gravel roads show the effect of automobile travel much less than those of broken stones. Macadam filled with sand of proper quality is much less damaged by automobiles than macadam consisting purely of the clean stone with the binding material used merely on the surface. Mr. Pillsbury stated that he had not noticed any tarviated roads in a slippery state yet. His construction outfit consisted of two kettles, one pair of horses, twelve to fourteen laborers and teams to haul sand and stone.

The next paper was on dust suppression in the Boston Park Department in 1907, by Mr. John A. Pettigrew, Superintendent of Parks, read by Mr. Shea. From 12 miles of roadway treated with oil in 1906, the treatment was extended this year over the whole system of roads, about 44 miles in all, with satisfactory results, the dust being laid perfectly. The cost of the oil treatment is cheaper than watering. The cost of watering was computed a few years ago at $489 per mile of 30 ft. roadway on 182 days in Franklin Park, and $883 per mile of 30 ft. roadway for the same service on 230 days on Commonwealth Ave. An average of $686.00 per mile is a very fair estimate for the entire system. From April 15 to Nov. 1 the cost of oiling has been $352.67 per mile of roadway 30 ft. wide, or 2 cents per square yard. The total amount used between the above dates was 1.49 pints per square yard. The dusty season is not quite over. There is a difference of $333 per mile in favor of the oil treatment. The watering practice is to water whenever the dust flies, if the temperature is not below 24° Fahr.

The asphaltum in the oil has a binding effect on the road surface, and less surface repairs are necessary. Less washing results from rains, and less gutter scraping is necessary. The softer footing on an oil-treated road is a benefit to horses, reducing the cost of shoeing. The oil is applied in the form of an emulsion. The first application of the season contains about 16 per cent. of oil to form a basis; renewals contain from 5 to 8 per cent. of oil, and are made in from 10 to 20 days, according to location and use of roadways. The emulsions are made by steam pumps, which do all the work of the transference and agitation of materials. To emulsify 2 barrels of oil, 18 lb. of common soap, at 4¾ cents a pound, are sufficient, with one barrel of water. This stock is taken on the work and supplies the ordinary sprinkling wagons, which do the work of applying the emulsion to the roads, the mixing in the sprinkling wagons being accomplished at the street posts or hydrants.

The Department is still in favor of a thin rolling cushion of coarse sand or fine screenings saturated with oil. This is, however, hard to maintain on curved roads, the swing of the wheels throwing it to the outer side of the curve. It is thought that this cushion releases the air suction below the tire, so destructive to the road binder. Fine or dead sand of a yellow color makes a pleasing surface, but if too heavily treated with oil an asphaltum surface will result, with tendency to scale. In the brief discussion which followed, Mr. Shea stated that the oil used is a Texas variety with an asphalt base, and that about two applications of sand were made during the season. The cost of sanding was not figured.

Mr. Charles W. Ross, Street Commissioner of Newton, then described experiments made in that city with road preservatives, chiefly on Commonwealth Ave. This thoroughfare, which is a continuation of the avenue of the same name in Boston, extends 5 miles through this residential suburb, and is divided into a north side used for teams, a central boulevard section used by trolley lines, and a south roadway, 36 ft. wide, used exclusively for automobiles. A section of 3,500 sq. yds. had hot tarvia applied during 1906, and went through the past winter excellently. Mr. Ross stated that the road was in better condition this year than last, and he attributed a smoothing down action on the tarvia to the rubber tires traversing it. Another section was laid with tarvia over an area of 28,843 sq. yds., at a cost on the average of 11 cts. this year. The road has a coating like india rubber. At Washington St., Newton Lower Falls, tarvia was used covered with ¼ in. sand and fine screened gravel, which gave better results than the flour of screened stone, which is dusty.

Asphaltoline was also successfully used on Commonwealth Ave. at a cost of 6 cents per square yard. Mr. Ross stated that oil does not save the surface of the road, but it stops the blowing off of dust. No complaint has been received from residents of Newton streets on which oil or tarvia has been tried. The cost of spreading Texas oil with machinery was 2.5 cents per sq. yard. A light coating of sand shaken on afterwards has been found to stop spattering. On another street in Newton the roadway was rolled with ¾-in. stone, and hot screenings mixed with 20 gal. of oil per cubic yard of screenings were spread with shovels. The work was done in June and the whole cost was 12 cents per square yard. The street has not been watered since.

Another experiment was tried on a section of Commonwealth Ave., where the roadway was worn down 2 or 3 in. lower at the centre than at the sides. A thin mortar made of 1 part Portland cement and 4 parts sand was swept upon the road with a broom at a cost of 7¼ cents per square yard. This has been in service, with very good satisfaction, since last June. The experiment was also tried of sweeping tarvia upon the cement to smooth it, and on a short section of roadway this has lasted well since the past summer season. A penetration of ¾ in. had been obtained with the tarvia put down a year ago. Asphaltoline went fully 1 in. into the macadam.

Col. Wm. D. Sohier, of Beverly, referred to the success of the calcium chloride treatment as a dust layer in Beverly last summer, and also outlined work done with oil. In using oil he urged putting enough material on top to permit the oil to come up through it. He emphasized the importance of not applying the oil in cold weather unless it is heated, pointed out the necessity of sloping the road first, and stated that the oil should not be allowed to go within 18 in. of the gutters. About half a gallon of oil per square yard is ordinarily adequate. Col. Sohier warned the members against leaving an oiled roadbed over night without gravelling the surface, on account of the washouts incidental to showers. Better results can be secured with calcium chloride and water than with water alone.

Openings Cut in Stack at Bissell's Point Preparatory to Wrecking It.

Mr. George Kimball, Superintendent of Streets, Manchester, stated that he used a tar and pitch composition, proportions not stated, on the top surface, mixed with egg and nut stone. This was applied in wheelbarrows with a rake, and no mud resulted. Dust was considerably reduced. Good results had also been obtained with calcium chloride. He had oiled 23 miles of road at a cost of 6.5 cents per yard, including spreading the top dressing of crushed stone, and had secured 2½ in. penetration below the surface.

Mr. A. B. Cowdery, of Boston, stated that the treatment of hollows in the roadway with tarvia and stone dust might cause the bunches previously referred to, unless the roadway were carefully surfaced first. Tarvia will not be smooth if the screenings are coarse when rolled into it. He emphasized the proper methods of handling such work from the standpoint of the tarvia representative.

Mr. Benjamin P. Richardson, president of the Calcide Process Company, discussed the classification of roads according to traffic, and stated that main arteries over which automobiles are allowed to run between towns at unlimited speeds are not advantageous subjects for calcium chloride treatment. This treatment is at its best in cities and towns where there is a large percentage of foot traffic. The treatment is odorless and spotless. Last summer a test was made under the supervision of the Department of Agriculture on a road in the government grounds at Washington. The road originally was built of trap rock, patched with limestone and then repaired a second time with trap rock. The upper and lower stones had ground the limestone to powder, and this dust had destroyed the binding properties of the surface. The first treatment with calcium chloride was in July, and since that time but two or three applications have been made. The road is now in very satisfactory condition. At Hingham, Mass., the calcium chloride treatment has been found cheaper than water, leaving no dust and mud, keeping new macadam moist and holding it in dry weather.

At Beverly Farms last summer 9.69 miles were treated, with an area of 108,013 sq. yd. This was treated for five months; the road was 19 ft. wide and over it passes heavy traffic at high speed. In one day 1,182 vehicles were counted passing in 10 hours, including 692 automobiles. The calcium chloride was applied by a new patented method, which loads a 600-gal. cart with a concentrated liquor and deposits 100 gal. each into six tins at the standpipes by the side of the road; when the cart is empty it turns around and syphons 500 gals. of water to 100 gals. calcium into its tank at each standpipe. The diluted liquid is spread on the road and the latter process repeated at each standpipe until the six tins are emptied. About four times as much work can be done in this way with one cart and a pair of horses as by the old method. It was found by a number of tests that a 600-gal. cart would cover an average of 3,800 sq. yd. per load and spread 28 loads of water per day at a cost of 2.4 cents per square yard, with three coats of water per day for seven months. Calcium chloride can be applied for a seven months' season at an average distribution of twelve 600-gal. loads per day, at a total cost, including the chemical, of 3.5 to 4 cents per square yard.

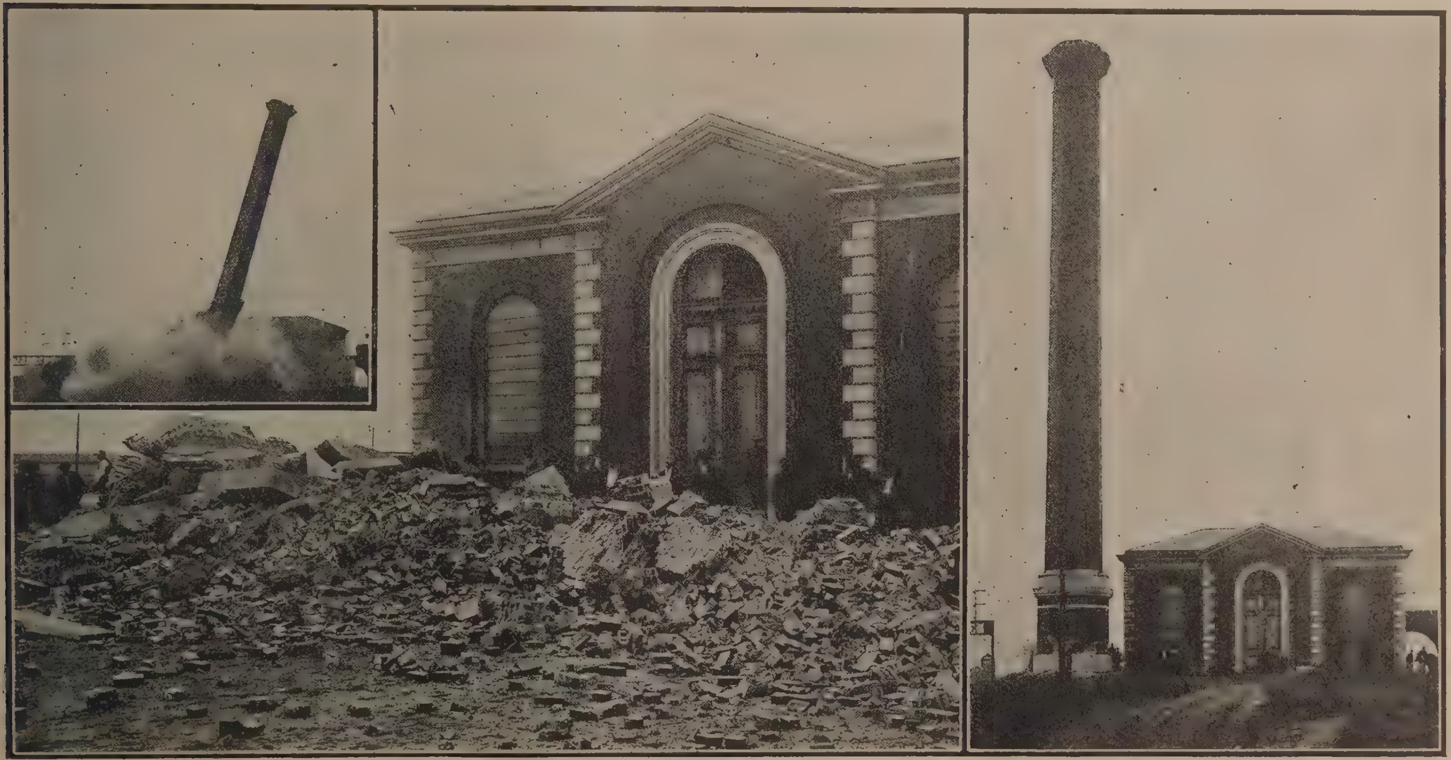
The Ore-Handling Arrangements at the works of the Bethlehem Steel Co. are rather unusual on account of the fact that the trains on which the ore is brought to the work come in on tracks considerably higher than the storage yard. As a result of this topographical condition the ore cars are run into a rolling car dump at the top of the retaining wall which bounds the high-level receiving track. This unloader is a long cylinder into which two cars are run at a time; these are then locked in place inside the cylinder which is rolled sidewise so that the ore is dumped over the edges of the cars, falling into hoppers at a lower level. These hoppers are located above a track on which cars can be run to receive the ore and take it directly to the furnaces. In case the ore is not to go directly to the furnaces, another type of car is run under the hoppers and transfers the coal a few feet sidewise to a long trough of concrete, which has a cross-section at the bottom approximately the same as that of a grab bucket. From this trough the ore is picked up by a bucket suspended from an ore bridge 550 ft. long over all, supported by two traveling towers 247 ft. apart on centers. This bridge covers the whole stock pile and enables the contents of the bucket to be dropped wherever desired.

Wrecking a Brick Smokestack.

By Edward E. Wall., M. Am. Soc. C. E.

On Sept. 28, 1907, the Water Department of St. Louis, Mo., threw down a brick smokestack at the abandoned low-service pumping plant at Bissell's Point. This plant has not been used for twelve years or more, but was kept in repair and the boilers under fire for emergency use, until 1903, when the fires were put out and the buildings closed up. A year later the engines and boilers were sold and removed. The buildings are substantial and in good condition, but this stack had been badly cracked along its entire length above the base, originally caused by being struck by lightning many years ago. It was strengthened by six steel hoops evenly spaced throughout its length. Lately the cast-iron cornice at the top opened up at the joints, and it was decided to throw it down before some portion of it fell upon the adjoining tracks of the Burlington railroad. There was danger that a portion of it might become dislodged by the jar of passing trains and fall upon a car and cause a wreck.

This stack was completed in 1871 and was built of hard hand-made brick laid in cement mortar. It stood at the southwest corner of the boiler house, about 10 ft. away, and not more than 15 ft. from the nearest railroad track on the west. There was about 45 deg. of available space to the southeast, where it could be thrown without causing any damage. This stack was octagonal in section, standing on a base of the same section 20 ft. 9 in. high, the walls of the base being 2 ft. 9 in. thick. The core wall was 8 in. thick, being separated from the stack wall by an annular space of 6 in.

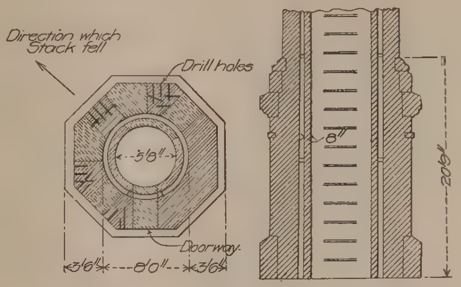


Views of the Brick Stack of the Bissell's Point Station, St. Louis Water-Works.

The outside diameter of the base, exclusive of the stone trimmings, was 13½ ft., the stack above the base being 11 ft. in diameter and 8 ft. 8 in. just below the cornice. The total height above the ground was 127 ft. 4 in.

Four openings, approximately 36 in. wide by 24 in. high. were cut through the 2-ft. 9-in. brick walls of the base, as shown in the illustrations. There was doorway 2 ft. 3 in. wide and about 5 ft. high, built through the base on the north side of the stack, which left four piers supporting the stack between the openings. The core wall was cut entirely away for about one-fourth of its circumference on the south side. Nineteen 1½-in. holes were drilled in these piers, of depths ranging from 12 to 24 in., and loaded with two sticks of dynamite each, about 20 lb. altogether. Two of the holes in one of the central piers were drilled in the sides of that pier, sloping downward at an angle of 45 deg.

The brick masonry of the base was very hard, making the cost of cutting and drilling excessive. The total cost of labor and dynamite was $97. The salvage was only about 20,000 brick, owing to the fact that the masonry was so well bonded together that the bricks did not readily separate at the mortar joints. The space covered on the ground by the wreck was 146 ft. by an average width of 20 ft., and the farthest brick was found 185 ft. away. The cost of clearing away the debris was about $175.



Position of Holes Cut in Stack.

No damage was done to the adjoining boiler house, and nothing whatever fell on the railroad tracks. The stack fell with its center line not more than 2 ft. from the location previously marked out for it.

The Mont Cenis Route, the oldest of the Alpine through lines, is to follow the lead of the St. Gothard and Simplon routes and employ electric traction on its mountain division. Under the stress of the competition of the more recent lines, the French government has also double-tracked the approach to the tunnel on its side of the mountains and the Italian government will carry this double-tracking to Turin.

Instructions for Foremen.

A manual of rules for construction, prepared and copyrighted by John W. Ferguson Co., Paterson, N. J., and New York.

General Foreman.—A General Foreman will be placed in charge of each job, he will be responsible for the care of tools, material and the property of this company, and the maintaining of harmonious relations with the Owners, Architects and Sub-Contractors (in other words, he will be the representative of the Company on the particular work where he is employed and be responsible for the results obtained).

Other Responsibilities:

1, That all records are properly kept by Timekeeper.

2, To examine all plans (original or corrected).

3, That old plans are cancelled.

4, That only latest information is used in executing work.

5, To examine all letters, instructions and other information coming to job—initial same and give to Timekeeper.

6. That danger signs are placed at all Elevators and all persons prohibited from riding on them.

7, That "No Smoking" signs are put up and the rule enforced as soon as any carpenter work is started or where the Rules of the Owners prohibit smoking on their property.

8, That all street obstructions are properly guarded by red lanterns at night, and all city or other ordinances are observed.

9, That the watchman properly attends to his duties.

10, To enforce Book of Instruction and any special instructions.

Sub-Foremen.—Sub-Foremen will be responsible for the work under their immediate charge and the final result obtained and shall be subject to supervision and instruction from General Foremen.

Timekeeper and Material Clerk.—The Timekeeper will be subject to instructions from the General Foreman.

Responsibilities:

He shall keep all records neatly and accurately in books and on forms furnished by Main Office. He shall do other clerical work as required by Book of Instructions, or special instructions.

Regular Records:

1, All men employed, time worked by each and the distribution of labor.

2, Number of men employed by Sub-Contractors.

3, All materials received (including checking, as unloaded, or delivered).

4, All charges for extra work against Owner, or Sub-Contractors.

5, He shall file all instructions, letters, schedules, etc., in such manner as to be easy of access. He shall see that the General Foreman has initialed all such papers and shall himself initial them also, before filing.

6, All records, files, drawings, etc., shall be preserved and delivered to Main Office when job is completed.

7, Duplicates (carbon sheets) of all orders, letters, instructions, etc., must be sent to the Main Office.

Drawings:

1, All drawings shall be properly cared for and preserved.

2, They should remain flat (not rolled) and be easy of access.

3, Drawings made void by new drawings must be plainly marked in red pencil, "Void."

4, Void drawings must be kept in a place separate from all other drawings and must not be destroyed except by some one in authority from Main Office.

Contract Number, Headings and Job Numbers:

1, All time and material shall be recorded and reported according to the Headings supplied by, or approved by, Main Office. This is absolutely necessary and applies to everything.

2, Each General Contract will be given an individual number, which shall be used in connection with all orders, reports, etc.

3, The word "Heading" is used to designate the divisions of work under the General Contract; also each individual piece of extra work done in connection with each General Contract under the classification of Day's Work, Unit Price Work or Extra Contract Work. In addition to the Heading each item of Extra Work will be given a serial number called Job Number, to aid the Main Office when rendering bills for Extra Work. The same Heading with Job Number must always be used for the same division or piece of work.

4, It should be borne in mind always by General and Sub-Foremen and by Timekeepers that the men in Main Office who are keeping the books are not familiar with the construction work and accordingly must depend upon the written information from the job, to make necessary charges and credits.

5, Any work in Original Contract and about which Timekeeper has any doubt as to the proper Heading shall be reported to Main Office, with request for information.

6, If there is occasion to start Extra Work, before Main Office has stated what Heading to use, the Timekeeper shall use a distinctive Heading approved by General Foremen, and promptly notify Main Office. Such a Heading shall be written the same always, or until changed by, or any change approved by, Main Office.

Labor.—Time must be taken at least four times a day, at the morning and noon starting times, and the noon and evening quitting times.

Distribution:

1, A statement showing the distribution of all labor according to the Headings and Job Numbers must be returned to Main Office each week, ending on the day for closing the pay.

2, The statement must show the number of hours at each rate of pay which were spent on each Heading, whether on Original Contract or Extra Work, or to be charged to Sub-Contractors.

Material.—The General Foreman will be furnished by Main Office with the following:

Copy of each order for material.

List of materials as ordered with dates for delivery.

Foreman's bill showing where material is to be used.

If above or other information is not received promptly, it must be asked for at once.

1, The General Foreman must note particularly the time stated for the delivery of each lot or item of material and promptly notify the Main Office if he thinks the date is too early or too late.

2, The General Foreman will be held responsible for keeping himself supplied with material. He must not take for granted that it is going to be delivered at the time mentioned in the order, but shall make inquiries as to its shipment from time to time and look far enough ahead to insure its being on the job when required.

3, To be properly supplied with material, will insure rapid and economical work.

Care of Material:

1, Any material which can be damaged by being exposed should be properly protected.

2, Cement and lime should be stored in sheds and raised off the ground to prevent its being affected by moisture.

3, Kiln-dried lumber should be properly stored under cover, preferably in a shed, if not, it should be well protected by canvas or boards.

4, Light lumber, such as beams, plank, boards, etc., should be properly piled when received and when not used immediately should be "stuck" so that it may dry out and not become water soaked.

5, Brick should be put under a shed or well covered with canvas during the Winter months.

6, All hardware and small supplies should be kept under lock and key and only given out as required for immediate use.

Receipt of Material:

1, The General Foreman must give all material a General Inspection before it is unloaded, particularly from cars or boats. If he finds that it is not up to the quality contracted for, he must not permit it to be unloaded, but at once notify the party from whom it was purchased (and at the same time the Main Office) that the quality is not what it should be, so that an inspection can be made by the seller before the material is unloaded or used.

2, Material delivered by team should be accompanied by invoice or delivery slip in duplicate, one to be signed and delivered to driver, and the other signed and returned to Main Office. If invoices or delivery slips do not accompany material, receipts in duplicate shall be made out on the proper forms, and treated in same manner.

3, Brick, sand, stone or other material delivered in large bulk can be receipted for by the use of tickets for each load, with a receipt at the end of each day for the full amount delivered.

4, Invoices or slips for material must be marked with the proper Heading (if for original contract so state), showing where material is to be used.

5, Material delivered on cars or boats must be tallied or measured as unloaded.

6, A separate report shall be made for each car or boat showing date received, car number and initial or name of boat, so that Main Office may identify each lot.

7, When lumber has been passed by an Official Inspector, a reporting showing merely the number of pieces received is sufficient.

Record of Material:

A complete record must be kept in a book for that purpose of all material received with the dates and other information for identification. This is in addition to the invoices and reports made to Main Office. A separate page in the Record Book must be allowed to each firm supplying material.

Transfer of Material:

1, All material transferred from one job to another, or from the Original Contract to any item of Extra Work, must be accurately tallied, and a report made to Main Office of such transfer the same day.

2, The report must show the Heading from which the material was taken, and the Heading to which it has been transferred.

Shortage and Damage of Material:

1, The General Foreman should compare the total amount of material delivered with the amount ordered, so that any shortage may be noted at once and not found out when too late to avoid delay in the work.

2, Invoices or slips shall be marked before returning to Main Office, indicating any shortage, defects or criticisms.

3, All shortages or damage of materials must be reported without delay to the parties furnishing it, either by General Foreman direct or through Main Office.

4, If material is damaged in transit, claim must be filed promptly with the Agent of the Railroad Company, and he shall be requested to inspect the material before it is unloaded. The Main Office shall be notified at once by letter of such action.

Tools.—Each job will be furnished with an equipment of tools necessary for the execution of the work. The General Foreman must make a list of his requirements before starting the job, and be responsible for having all the tools required on hand before they are actually needed. The General Foreman will be responsible for their proper care and return when the job is finished, also that any necessary loss or damage does not occur. Any shortage or breakage must be accounted for.

In an Emergency, the General Foreman is authorized to purchase special equipment required, but he should endeavor to look far enough ahead so that what he requires may be supplied from the Yard or purchased by Main Office. Report must be made immediately upon the purchase of special equipment, noting the urgency which demanded it.

When the job is large enough a Storekeeper should be placed in charge of all tools, equipment and small supplies, who shall be held responsible for their general care and for any losses which may occur. In case it is advisable to employ a Storekeeper, the General Foreman should designate some one to look after the tools and equipment, to insure their being properly cared for and not lost, stolen or destroyed, or left lying around when not in use.

The General Foreman must see that the equipment of tools and scaffolding or material is not wastefully used, cut up or destroyed, and he cannot be too strongly impressed with the necessity of enforcing this rule, when a tendency to violate it is shown by any one in his employ. This should be done at the start and not after it has become a habit with some workmen.

Any part of the equipment which becomes damaged or unfit for use should be set one side separate from the other tools and returned to the Yard for repairs at the earliest possible moment. All the equipment should be kept in condition for use, by temporary repairs, if possible on the job.

Inspection of Tools:

1, If any tools are transferred to another job, report should be made promptly to Main Office so that the General Foreman can be credited for the tools. An original and duplicate slip should be made out, the original being sent to Main Office, and the duplicate given to driver of team, who must have it signed by the person receiving his load. It should then be mailed to Main Office. (When shipments are made by Railroad, the duplicate slip must be mailed).

2, A correct account of all tools received and sent away from the job must be entered on Form headed "Tool Account," so that at any time during the progress of the work, just what tools are in use can be seen.

3, This record must be sent to Main Office promptly, when the job is finished.

4, Sub-Contractors must not be allowed to use this Company's tools, scaffolding or equipment, except where special arrangements have been made for such use. The General Foreman must see that the equipment, so loaned, is returned in good condition, and that any which may be lost or damaged are charged to Sub-Contractor.

5, General repairs of Engines, Boilers and heavy equipment not to be made on the job without special instructions.

6, The General Foreman should see that the equipment furnished him is in proper shape and if not, immediately report its condition to the Main Office.

7, General Foremen must examine and see that all material used for scaffolding, derrick blocks, etc., is in perfect condition. All scaffolding must be built of material selected for that purpose and it should be constantly examined to see that it is properly constructed and in proper condition.

8, All derricks must be carefully examined before being put in service and frequently examined to see that they are safe and in perfect working order. Derrick booms should be lowered and properly lashed and fastened when not in use.

9, All rope, blocks, chains and other appliances for handling material must be examined and none used which show the slightest indication of defect.

10, All ladders must be carefully inspected to insure their being in perfect condition, and sufficiently heavy for the use to which they are placed.

Paying Off.—General Foremen and Timekeepers must observe the following regulations in distributing the money on pay day and at other times:

Pay Day:

1, The General Foreman must be present when the men are paid, to identify them, and personally check each name on the pay-roll as the money is delivered to the man. After paying off, the pay-roll should be signed by both General Foreman and the man distributing the money, certifying that the names checked have been paid.

2, On pay day, the General Foreman must Compare Discharge Tickets with Unchecked Names on pay-roll and Envelopes left over and mark the letter "D" next names of discharged on payroll.

Envelopes Left Over:

1, A list should be made out immediately after paying off of the names and amounts of all the envelopes left over, on form headed "Report of Employees Unpaid," and the original of this list returned to Main Office with pay-roll sheet.

2, Each envelope retained by General Foreman shall be marked at once with the date of pay day, and Contract Number, and held by him until called for (not to exceed one week). If not called for in one week, the envelope with the money therein shall then be returned to Main Office.

Paying After Pay Day:

1, If a man calls for his pay within one week after pay day, he must sign a receipt for his pay on the special Pay Receipt Form provided for that purpose. This receipt must be sent to the Main Office promptly.

2. No money shall be paid to any one but the party to whom it is due, except upon a written order from said party, and the party receiving the money on such order must be properly identified.

3, The order must be sent to Main Office with the receipt of the party to whom payment is made.

4, If a man calls for his pay more than one week after pay day, his name and address should be taken and sent promptly to Main Office, stating the amount of his back pay. Upon receipt of such request Main Office will send a Special Pay Roll Check to the man at his address for the amount.

Pay Receipts:

The General Foreman will be supplied with books of Pay Receipts and should carry one in his pocket. He will fill out one of these and have it signed by each man discharged; also by men paid on job for previous week. The receipt must be sent at once to Main Office, and stub filled out and retained by Foreman.

Daily Reports.—The Daily Report must be made every day on a blank furnished for that purpose, showing the following:

Number of men employed in each class of work and where they are working.

Number of men working for Sub-Contractors.

Commencement of any particular part of work.

Receipt of Material for Sub-Contractors.

Time Sub-Contractors start and finish their work.

Receipt of important and special material.

Report of any accident or damage to work.

Condition of weather when work is prevented.

A special letter must accompany daily reports, covering important matters that cannot be embodied in the regular report.

Sub-Contractors.—General Foreman must inspect, and be responsible for, the quality of work done by Sub-Contractors. He shall see that proper progress is made, and that Sub-Contractor is given sufficient notice ahead of time as to when he is required on the job.

Sufficient notice does not mean one day's notice, but time enough for Sub-Contractor to secure his men and material.

Labor or material must not be furnished a Sub-Contractor except upon a written order, and daily charge slips signed for the same and sent to Main Office.

Accident Reports.—In the event of any accident, however slight, happening to any one on the work, whether in the employ of the company or not, it is absolutely necessary that a detailed report of such accident be made promptly in writing on the blank furnished for that purpose.

These reports, and all data connected therewith, must be written with Indelible Pencil.

If any accident, the report must cover all the facts in detail. In case the accident is of a serious nature, a complete statement must be obtained from the injured person and all witnesses, in writing, and their signatures to such statement, witnessed by a second party.

In case of accidents which are liable to prove fatal these statements must be sworn to before a Notary Public, and Main Office notified without delay. Photographs should be taken in such cases, if possible, before anything has been disturbed.

In case of accident of serious nature an investigation will probably be made by an Examiner, who should be given only the actual facts in the case. Any information beyond this must be procured by him from Main Office.

The General Foreman must see that tools, materials or equipment that caused the accident are removed if possible to his office, properly marked and preserved.

In case of doubt or any misunderstanding on the part of the General Foreman, Main Office should be consulted as to what information is considered necessary as a record of the accident.

Where the injured person remains at work, this must be stated on the Accident Report, and in cases where they are taken to the hospital, frequent inquiries must be made as to their progress and a report made immediately to Main Office. Main Office must be advised of the Return to Work of any person injured.

Car Demurrage.—All cars should be unloaded immediately, unless there is a good reason for not doing so as in case of damage or shortage, as a demurrage charge is made by the Railroads, for cars held more than forty-eight hours after they are placed on the siding.

A monthly time book may be used for recording the number and initial of each car (noting what it was loaded with), the date of its arrival, and the date it was unloaded. In case of a small job or only a few cars, this record can be kept in some other book, but a record must be kept in all cases.

Cartage.—Cartage for each class of material must be kept separate and a report made of the total cost of cartage of material when the hauling is completed. This report, together with a complete record of the distribution of all cartage is to be returned to Main Office once a month, and upon the completion of the job.

Diary.—A diary must be kept on each job showing a daily report of what transpires, such as:

Condition of weather.

Temperature (with thermometer readings at 8 a. m., 12 m. and 5 p. m., during the winter months).

Notation of visitors (Owner, Architect or any one from Main Office).

Starting of all divisions of the work.

Starting of work of Sub-Contractors.

Arrival of material, and of Outside Contractors not under our control.

Records of accidents.

Taking possession of the building by the owners.

Diary records should be briefly noted on Daily Reports.

Telephones.—Where the job is supplied with a special telephone it must be used only for business purposes. All calls made by sub-contractors or individuals must be noted and charges made against them. Post conspicuously, adjacent to the telephone, telephone numbers for Ambulances, Hospitals, Fire Department and Police Department.

Cement Bags.—Care must be taken to have all empty bags collected and kept dry with as little damage as possible so that they may be returned to the parties from whom the cement was purchased and due credit may be obtained by this Company. The General Foreman will be expected to account for any excessive loss from this source.

Main Office will furnish shipping tags and full instructions for the return of empty bags, but care must be used in every case that none but the bags marked with the respective company's trade or brand of cement mark are sent to them.

On making shipments Bills of Lading must be made out in duplicate, and both copies together with a material slip showing number of bundles and total number of bags shipped forwarded at once to Main Office.

Extra Work.—Any work not included in Original Contract, shall be known as Extra Work, unless Main Office should instruct otherwise, and will be done under the following classifications:

Extra Contract Work: Where a fixed amount covers all labor and material for the work under one Heading.

Unit Price Work: Where a fixed amount per unit of work covers labor and material, such as price per yard, per thousand, etc.

Days Work: Where the actual labor and ma-

materials are charged for at cost plus a percentage.

Authority for Performing Extra Work:

1, We should like to make it an invariable rule that Extra Work should not be started except upon properly written authority from Main Office in regular form, with Headings and Job Numbers designated. We recognize, however, that it is sometimes necessary to start Extra Work before receiving written authority from Main Office. In such cases General Foreman should call for written authority from Owner before starting the Extra Work, and should send to Main Office this written authority the day that he receives it.

2, If it should be necessary, in the judgment of General Foreman to start Extra Work upon being requested to do so by Owner, or his proper representative and without any written authority whatever, General Foreman should immediately notify Main Office, stating all the circumstances.

Reports of Extra Work:

1, When so requested a Daily Charge Slip for each item of Extra Day's Work shall be furnished to Owner, (unless so requested Daily Slips need not be made at all).

2, If Daily Slips are made a (carbon sheet) duplicate shall be made also, and held on the job until end of week, at which time they shall be attached to Weekly Charge Reports, and sent therewith to Main Office.

3, Weekly Charge Reports for labor, shall be made for each item of Extra Day's work. These shall show the class of labor (whether mason, carpenter, etc.), the number of hours worked of each class, at each rate of pay. They shall be sent to Main Office at end of each (pay) week.

4, If so requested (carbon sheet) duplicates shall be furnished to Owner.

5, Charge slips for material shall be made each month, or immediately when each item of extra work is completed, and shall show the quantities, kind of material and from where it came. These slips shall be sent to Main Office promptly.

6, A bill, on Extra Work Bill form, including labor and material for all Unit Price and Day's Work under its respective Heading and Job Number must be sent to Main Office as soon as any item of the work is completed.

7, In case such work extends over a period longer than one month, a bill must be returned to the Office at the end of Each Month, showing the amount of labor and material furnished for each individual item, such bill to be clearly marked "Unfinished."

8, Prices of material, when known, to be inserted in pencil in column designated "Prices"; only one item to be entered on a line.

9, Remember that the men in Main Office depend on these Extra Work Bills to charge the work against the party to whom it is furnished.

Sub-Contractors on Extra Work:

1, No Extra Work shall be done by a Sub-Contractor except upon an order in writing from Main Office. In case of Emergency, the General Foreman may order Extra Work, but must notify Main Office so that it can be confirmed immediately by a regular order.

2, No Extra Work shall be done by a Sub-Contractor except upon an agreed price either at a lump sum, or unit price for the labor and material. In the latter case the time and material must be checked daily and reported to Main Office.

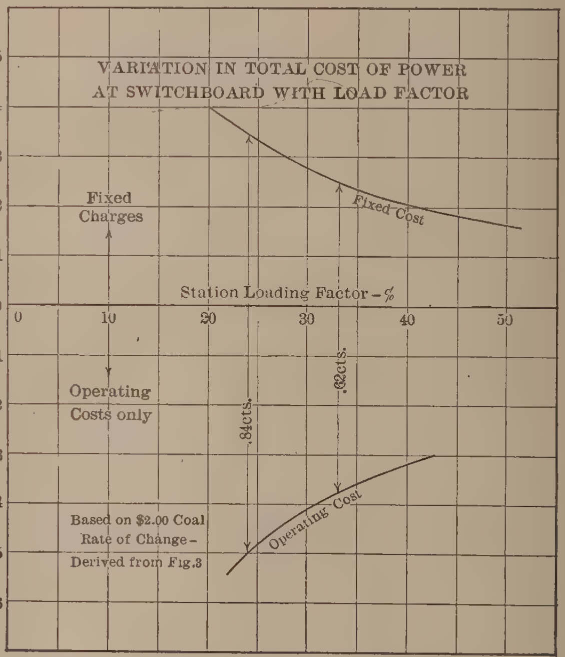
Orders by General Foreman.—In cases of necessity the General Foreman may order material and give an order for work to be done by Sub-Contracts, on Order Forms furnished for that purpose, sending a duplicate (carbon sheet) at once to the Main Office. On the carbon sheet write a full explanation of why and for what purpose the material was ordered, and the necessity for any item of work ordered of a Sub-Contractor.

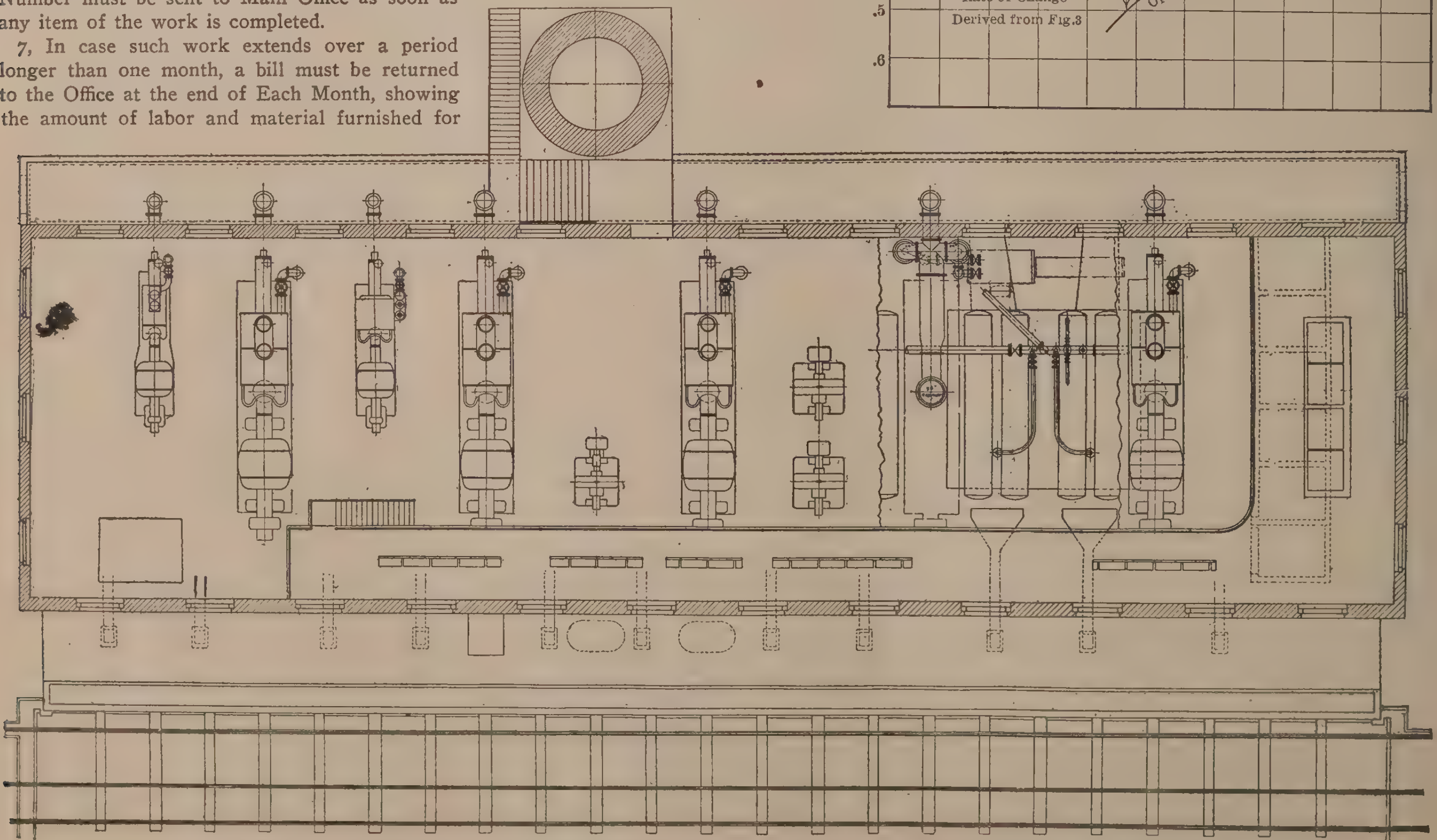
Relocation of Line on the Columbia & Port Deposit branch of the Pennsylvania R. R. has been recently completed along some thirteen miles of the Susquehanna River, which will be raised by the McCall Ferry power development. The new double track line had to be built on steep rocky bluffs, making the work so dangerous to trains on the old track at a lower elevation that regular service was entirely abandoned.

The Spy Run Station of the Fort Wayne & Wabash Valley Traction Co.

The Spy Run station of the Fort Wayne & Wabash Valley Traction Co. has been arranged along decidedly novel lines and presents an interesting example of the engineering possibilities of turbine plant construction. At the recent convention of the American Street & Interurban Railway Engineering Association, the station was described at considerable length by Mr. J. R. Bibbins, from whose paper the following account has been abridged.

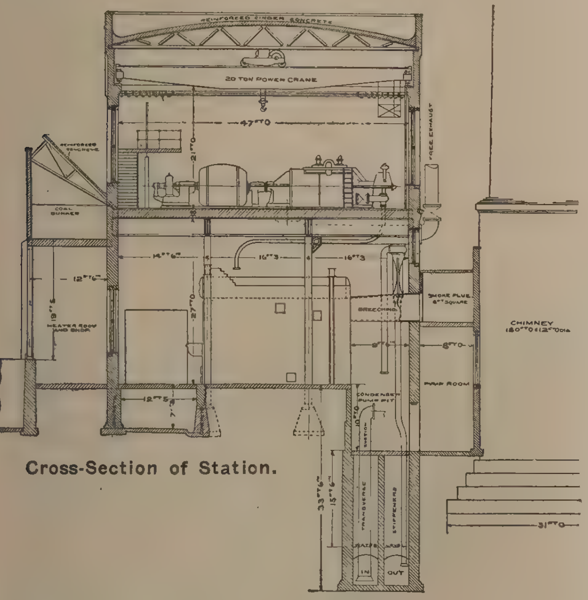
Like many other similarly situated railway concerns, the company has adopted the policy of developing light and power business in connection with its traction system, serving both traction and lighting systems from a central power station, as previously outlined. In the city of Ft. Wayne, this business has assumed such proportions that nearly one-half of the new power station is devoted to 60-cycle lighting equipment, the remainder to 25-cycle equipment for traction pur-





General Plan of the Spy Run Power Station of the Ft. Wayne & Wabash Valley Traction Co, poses. High tension transmission lines parallel the railway from Fort Wayne to Lafayette, a total transmission distance of 112 miles from the source of supply. En route, the lines touch Wabash, Logansport, Huntingdon, Peru, and numerous smaller towns, in most of which considerable lighting business is available. Along this route are eleven rotary converter substations ranging in capacity from 200 to 500 kw., totalling 3,600 kw., or somewhat in excess of the present station generating capacity. But as the maximum demands from these substations do not superpose, owing to the distribution of cars, there results at the station an unusually uniform load for traction work.

The site chosen parallels a small stream—St. Joseph's river—from which the water supply is drawn for both feed and condenser purposes. Owing to the contour of the country, 25 ft. difference in level between river bed and station floor was unavoidable. A lower location would not only have introduced difficulties in coal trackage, but also would have endangered the station at periods of excessive flood, to which the stream is liable.



Cross-Section of Station.

The principal features of the station may be summarized as follows: (1) A two-story, rectangular brick structure with side wings for the accommodation of auxiliary apparatus, coal bunker, machine shop and stores. (2) Generating machinery on second floor over boilers. (3) Structural foundation with concrete arch floor construction. (4) Independent barometric jet condenser—moderate vacuum. (5) Gravity conduit system for cooling water. (6) Independent, direct-driven exciters—common bus for each system. (7) Steam piping—simple, short and direct, with continuous upward slope from boiler nozzle to turbine throttle. (8) Sufficient superheater surface to maintain dryness, or moderate superheat at beginning of expansion in the turbines—100 deg. to 125 deg. at the boiler. (9) Mechanical stoking with gravity fuel feed. (11) 6,000-ton (two months') coal storage, served by gantry crane. (12) Steam-driven auxiliaries for feed heating. (13) System of forced ventilation for turbo-generators. (14) Fireproof transformer compartments, with transformers mounted on rolling trucks to facilitate removal. (15) Remote control oil circuit-breakers with time limit overload relays.

Essentially the station represents an attempt to produce a power property that will show to best advantage in the balance sheet with a medium price coal—one in which the absence of engineering "frills" for securing the highest efficiency, is compensated for by lower capital cost. This should be borne in mind in the discussion of the operating results later noted.

The building construction in turbine power plants is largely influenced by arrangement of boiler equipment. In this case it was apparent that a somewhat lower boiler capacity than usual would be required for the combined service. For moderate-sized units, a well-equipped boiler room requires from 2 to 2.5 sq. ft. per boiler horse-power, in some extremely compact arrangements, requiring as low as 1.5 sq. ft. per boiler horse-power. The Fort Wayne arrangement works out 1.75 sq. ft. per boiler horse-power. Assuming a capacity ratio of 0.6 boiler horse-power per kilowatt, the floor area then works out slightly over 1 sq. ft. per kilowatt for boiler room alone.

Now, for a fairly compact generating room in a station of this size, from 0.75 to 1.15 sq. ft. per kilowatt are required. But for the Ft. Wayne plant, some provision had to be made for the accommodation of direct-current sub-station apparatus. Assuming 1 sq. ft. per kilowatt as a reasonable area, we find that this practically coincides with the above boiler room area. The designer thus had two alternatives: First, a double decked power station, or, second, a building of twice the area with two equal-size operating rooms in parallel and under one roof, which arrangement would be preferable. From an investment standpoint, it is hardly open to question. As it stands, the building cost about $12.50 per kilowatt, including additions, which is by no means excessive.

Inseparable from this building arrangement is the question of structural foundations, which are entirely justifiable in the cases of steam turbines owing to the absence of cyclical movement arising from unbalanced parts requiring in the case of low-speed reciprocating engine the most rigid foundations. Moreover, there was ample precedent for this type of foundation structure, notably the two turbine stations of the Philadelphia Rapid Transit Co.

The floor structure of the Ft. Wayne station is shown in detail in an accompanying illustration. It consists of individual pairs of transverse plate girders extending across the building under each turbine bed plate. Short cross girders serve to tie the longitudinal girders together at column intersections, the whole forming bents or cradles between the several generating units. Box columns divide the building width into practically three equal spans, these columns rising between the several boiler batteries. Thus the weight of th generating machinery is distributed between two building walls and two rows of columns. Only in the case of the smaller machines and rotaries does any of the weight fall upon the areas intervening between columns. In order to insure even settling, the precaution was taken of carrying footings for both columns down to practically the same level so as to encounter homogeneous strata.

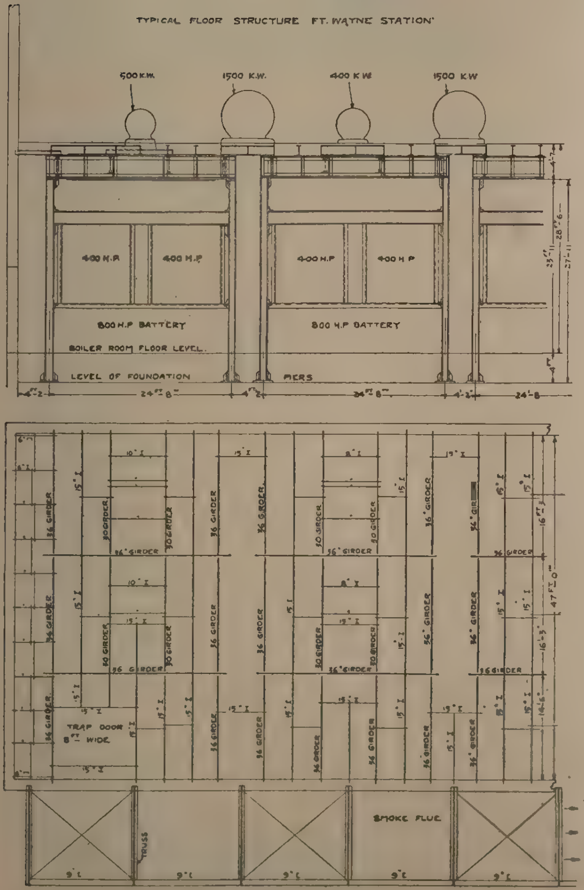
TABLE OF DATA OF POWER HOUSE.

Dimensions of building, ground floor plan (47 ft. by 177 ft. 2 in.)	8,340 sq. ft.
Dimensions of building, condenser room (9 ft. 6 in. by 177 ft. 2 in.)	....
Dimensions of building, pump room (8 ft. by 177 ft. 2 in.)	1,419 sq. ft.
Dimensions of building, heater and pump room (12 ft. 6 in. by 173 ft.)	2,160 sq. ft.
Total area of power house	11,919 sq. ft.
Total area of power house, single deck basis.	20,273 sq. ft.
Height boiler room, 28 ft. 6 in.; turbine room to crane rail, 21 ft. 7 in.	
Present capacity, 60-cycle, 3,500 kw.; 25-cycle, 3,500 kw.	7,000 kw.
Utimate capacity	8,500 kw.
Ultimate capacity, entire plant max. rated overload	12,750 kw.
Present substation capacity, 1,300 kw. ultimate	2,600 kw.
Present boiler capacity, 10—400-h.p.	4,000 bo. h.p.
Ultimate boiler capacity, 12—400-h.p.	4,800 bo. h.p.
Relative area—	
Station, ground floor plan	1.39 sq. ft. per kw. ult.
Station, single floor plan	2.39 sq. ft. per kw. ult.
Operating room (floor plan)	0.98 sq. ft. per kw. ult.
Operating room (exc. high-tension and sub-station equipment)	0.722 sq. ft. per kw. ult.
Boiler room (net floor plan)	1.74 sq. ft. per bo. h.p.
Total boiler room and bunker	2.19 sq. ft. per bo. h.p.
Boiler settings (24 ft. 8 in. by 23 ft. 5 in.)	0.725 sq. ft. per bo. h.p.
Relative boiler capacity, ultimate.	0.56 bo. h.p. per kw.

It is apparent from the illustration that the location of the large turbines was chosen so as to accommodate under each floor bent a single battery of boilers. With the small boiler units chosen, this, of course, provides a larger turbine room above than is necessary; but, by utilizing the excess floor space for substation apparatus, this disadvantage is largely overcome. The floor plan of the equipment arrangements shows to what advantage the space has been utilized.

It is noteworthy here that with larger boiler units, a far more compact arrangement would be possible with little increase in floor span between batteries.

This relative disposition of boilers and turbines evidently permits of the simplest form of piping. Strictly on the unit principle, this would involve but two bends, as shown in the cross-sectional drawing. The addition of an equalizing header running the length of the building then complicates the piping only to the extent of extra valves, fittings and hangers, resulting in: (1) Most direct path of steam from boiler to turbine; (2) Equalizing connection to compensate for varia-



Turbine Room Floor and Supports.

tions in the rate of steaming of boilers in service; (3) Provision for most convenient distribution of boiler capacity to carry any load; (4) A cost of $2.50 per kilowatt for steam piping, complete.

In the normal operation of the plant, effort is made to keep those boilers in service nearest to the turbines in operation, thus giving the minimum distance of steam flow. When occasion arises, the plant may be operated on the unit system, valves in the header between the various risers being supplied for this purpose.

Superheaters were installed principally for the purpose of insuring thoroughly dry steam at the beginning of expansion in the turbine. Although the presence of moisture in the steam system is not encountered in normal operation, the precaution was taken of delivering steam from the boilers underneath and discharging it above the header, so that a continuous draining is provided from turbine throttle back to boiler. This is likely to be an advantage in starting a section of the plant that has stood idle for a time.

In the arrangement of the breeching, the main smoke flue might have been run inside the boiler-room walls, thus avoiding the breech connection shown in the cross-section. This, however, would have necessitated locating the condensers outside of the building. With the present arrangement, a 10-ft. space back of the boilers is ample for all condensing apparatus, and the space under the external smoke flue is utilized as additional boiler-room area for small auxiliaries, oil filters, and the like.

Superheated steam is provided direct from the main to all principal auxiliaries in the plant. This avoids an auxiliary steam main. According to customary practice, the auxiliary main draws its supply from opposite extremities of the steam system so as to avoid to the greatest degree possible a shut-down of auxiliaries. At Fort Wayne nearly the same security is provided by connecting auxiliaries directly into the steam main at different points. Thus boiler feed pumps are connected in duplicate to opposite sections of the steam main, each of which is supplied by at least four boilers. Similarly, condenser pumps are connected to the same section of the main as the turbines which they serve. If a turbine unit is disabled, the pumps will not, of course, be needed.

The absence of economizers will be noted. These were not considered necessary with coal at $2 to $2.50 per ton. For feed heating auxiliary exhaust steam is entirely relied upon, all boiler, service and condenser pumps, also fan and stoker engines contributing heat through the medium of open heaters. Exciters are direct-driven. Nevertheless, a feed temperature of 160 deg. to 180 deg. is obtainable during the day, and 200 deg. at night. This feed is drawn from the hot condenser discharge tunnel and delivered to elevated tank, which provides a static head on the heaters and are of sufficient capacity to supply the plant for three hours at full load. Similarly the heaters are elevated a few feet to insure a positive lift of feed pump valves. With this feed system, boiler cleaning is not necessary oftener than at monthly intervals.

Mechanical stoking was adopted not only to minimize labor cost, but also to provide ample forcing capacity for peak loads or emergencies. With Hocking Valley screenings, three men can handle without difficulty ten boilers, or 1,330 boiler horse-power each. Hand firing for the same capacity would require ten firemen and two water-tenders, or 400 boiler horse-power per fireman, a reduction of 60 per cent. Present boiler-room labor, averaging $11.75 per 12-hour shift, would be increased to about $28 per shift, providing 12-hour shifts could be maintained.

The character of river water had, of course, an important bearing on the design of the condenser system. Although carrying considerable sediment at times, the water is extremely soft and develops no hard scale even after many weeks of continuous running. This annulled the principal advantage of the surface condenser., viz.: return of pure exhaust steam for feed water. The 25-ft. difference in level between ground floor and low water made one of two condenser systems imperative: (a) Surface condenser with continuous pipe loop (balanced water column), with power-driven circulating pumps to overcome fluid friction. (b) Barometric jet condensers mounted near the level of turbine exhausts with tail pipes extending downward to the normal river level, with power-driven circulating pump to overcome excess barometric head.

With the former, dry vacuum pumps would be imperative in order to prevent the condensers from becoming air-bound, or losing their vacuum altogether through air leaks in the water system, thus adding another auxiliary. Moreover, the surface type of plant is extremely bulky and would have seriously interfered with the "double-decked" layout.

On the other hand, the barometric type fits particularly well into the scheme. The condenser head may be suspended beneath the turbine, where its most bulky part is out of the way. The tail pipes may then be carried down at any angle or turn sufficient to clear necessary obstructions. Thus the 9.5-ft. area way which would ordinarily be provided in the rear of the boilers is conveniently utilized as operating space.

With the arrangement employed, a difference of about 47 ft. exists between the condenser head and low water level. This, however, does not interfere with the operation of the condensers, as a partial void simply results in the upper part of the barometric column.

The use of twin condenser units permits the use of less bulky apparatus, and also makes it possible, in the event of the disablement of one side, to continue operation on the other with reduced vacuum. Long stroke reciprocating pumps were chosen for this purpose instead of high-speed centrifugal pumps, as being best suited to the high lift, 16 ft. With this type of pump, a small air chamber will suffice to carry over the moment of reversal without any dip in vacuum, which would otherwise accompany the non-uniform flow of injection water. This equipment without dry vacuum pumps yields a vacuum during warm weather of about 26.5 to 27 in. at full load, referred to 30-in. barometer. Its simplicity and ease of upkeep is apparent, especially in view of the low cost, about $2.50 per kilowatt, including pumps and piping, but no tunnel work.

Water is conducted to and from a screen house on the river bank entirely by gravity through a double-duct concrete conduit. At the river a double screen prevents debris from entering the intake, which is at right angles to the current, while the discharge is down-stream. This conduit system, of course, necessitated considerable excavation in the rear of the boilers. The two retaining walls were then reinforced at intervals by transverse stiffener arches sprung across the pit.

The Ft. Wayne plant uses normally about 100 tons of coal per day. In the provision for coal storage, an elevated bunker of relatively small capacity (400 tons) fulfils all requirements for gravity feed. Even this would tide the plant over a period of at least three days in case of failure of coal-handling apparatus. The main storage yard will contain about 6,000 tons—sufficient for two months' supply, but only about 4,000 tons is ordinarily held in stock, except in case of impending fuel shortage. The gantry crane serving this storage yard combines the function of unloader, crusher, elevator and distributor. Its efficiency is attested by the fact that while its normal capacity is considered to be one 50-ton car per hour, the operators have unloaded a 40-ton car in 16 minutes, and a maximum of eleven cars (500 tons) in a short working day. The crane is electrically operated from a controller tower by one man.

The two sections of the generating plant, 25-cycle and 60-cycle, are, of course, separated electrically, and each therefore controlled by a separate switchboard. Two additional boards control the rotary converter output for both 25-cycle and 60-cycle systems, the latter consisting of a direct-current power circuit for elevators and other intermittent power. A fifth board controls the exciters. With perhaps the exception of the exciters, the generating plant is quite standard throughout. In place of the usual steam-driven exciter unit, with motor-driven duplicate, each generating unit is provided with its own direct-connected exciter, all generating at the same voltage—125 volts. Each exciter has sufficient capacity to carry two generators. All may be connected to a common bus, as an emergency condition. Normally the 25 and 60-cycle exciters are separated to permit the use of independent voltage regulators.

Assuming the case of instantaneous fluctuating loads, the voltage regulation of a direct-connected engine-generator-exciter unit is not, of course, comparable with that of steam-driven exciters, due to cumulative drop in speed and voltage. Of the three systems (a) independent steam-driven exciter, (b) independent motor-driven exciter, (c) exciter-driven by prime mover, the first undoubtedly gives the best results. But with the use of the automatic voltage regulator, the three are brought practically to an equality.

This subdivision of exciter capacity assures uninterrupted service to a degree quite impossible with the usual arrangement of independent exciters, and almost to the same degree as the standby storage battery quite frequently employed as an insurance against current interruptions. With half the exciters in the station inoperative, there would still be ample capacity remaining.

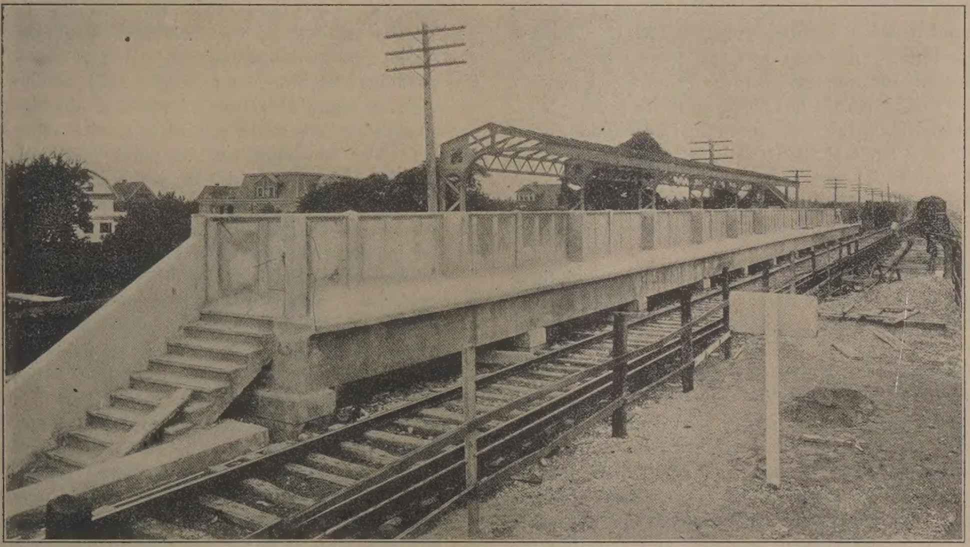
These direct-connected exciters add 2.6 per cent. to the expense of the main generating unit. A detailed comparison of the total cost of the exciting plant, as compared to the cost of an inequivalent independent exciting plant, including reserve unit, shows some 20 per cent. in favor of direct drive.

All the generators draw their supply of ventilating air from a sheet steel duct running the length of the plant above and in front of the boilers. This has served its purpose, but a positive pressure fan has been installed as an auxiliary to accelerate the air flow during certain prevailing winds when the required draft is more difficult to maintain through the long supply duct. This system of positive generator ventilation has the advantage of maintaining low generator temperatures the year around, while by means of the fan auxiliary a large excess of air can be supplied to any of the units that may be for any reason abnormally overloaded. In other words, the fan blast may be regarded as a generator auxiliary. It makes possible greater generator overloads.

In some large turbine plants of recent design where considerable distance must necessarily intervene between switchboard operator and turbine throttle, it has been found desirable to control the running speed entirely from the switchboard by a small motor-driven mechanism connected to the governor. This system has undoubtedly advantages from an electrical standpoint in synchronizing and distributing load. Yet in compact stations such as Ft. Wayne, it seems a better plan to commission the engineer in charge with entire authority over the mechanical equipment, as is the case. All speed adjustments are taken care of at the individual governors by the engineer or from the switchboard.

Designers of large plants also tend to concentrate in a continuous return cooling and filtering system, the usual independent oil system used on these turbines. At Ft. Wayne, however, the independent system has been used, largely with the intention of isolating trouble in so important a function as the lubrication. Each turbine has its own oil pump, cooler and strainer reservoir, all of which apparatus is readily accessible from the engine-room floor. When desired, however, the oil may be entirely drained out of any of the machines into the filter below, where it is screened, washed and returned by a small steam pump.

In the final analyses of the ultimate cost of power, fixed or capital costs, of course, have an important bearing, and it is in this regard that the type of station described exerts its strongest influence. In the preceding discussion, it has been the object to show wherein the double-decked station has made the greatest advance along engineering lines. Owing to the absence of many refinements, it is evident that the maximum possible efficiency could hardly be obtained. In compensation, we should look for a considerable reduction in the capital charges in order to bring the total cost of the power generated to as low a point as would result from the use of a more efficient plant. This proves to be the case with the Ft. Wayne station.


Completed Concrete Platform Fence on Brighton Beach Line, Brooklyn, N. Y,

Analyses of the total power costs from modern steam plants of 5,000 to 10,000 kilowatt capacity shows that the capital costs, including interest and depreciation, amount to about 50 per cent. of the total. For such high-grade stations, with thoroughly modern equipment, we should expect an investment cost of from $150 per kilowatt in the smaller, down to $100 per kilowatt in the larger sizes. In a few very large stations the investment cost has been less than $100 per kilowatt, but for stations under 10,000 kilowatt it very rarely occurs that the cost is below the above figure. The Ft. Wayne station is thus unique in having set a new standard for power-station cost which may well be emulated in cases where turbine machinery is applicable. The table shows the cost of the complete station, exclusive of substation apparatus, but including main line transformers—a total of $66.25 per kilowatt generating capacity.

In this summary, the building cost is naturally high, owing to the large amount of structural material necessary. On the other hand, boiler and condenser costs are extremely low, for reasons previously set forth.

Cost of Completed Power Station, 8,500 kw. No Substation Apparatus.

	Total.	Per Kw.
Building, including general concrete and steel work, galleries, coal bunker, smoke flue, condenser pit, coal storage pit, etc.	$93,217	$10.97
Generating plant, including turbines, generators, exciters, cables, switchboards, transformers and ventilating ducts	259,711	30.55
Boiler plant, including boilers, superheaters, stokers, piping, pumps, heaters, settings, breechings and tank	118,313	13.92
Condenser plant, including condensers, pumps, piping, free exhausts, water tunnels and intake screen	33,790	3.98
Coal-handling plant, including gantry crane, crusher, motors and track	7,990	0.94
Erection superintendence, engineering and miscellaneous	50,500	5.94
Total, excluding property and siding	$563,520	$66.25

Using as a basis the above costs, and the rate of variation with loading factor, the ultimate total cost of power at different loading factors may be predicted; in other words, the total financial result of station operation. The diagram has been prepared along these lines. Fixed charges are dealt with entirely above the horizontal line, and operating costs below. The total power cost, at a given loading factor, is then represented by the total vertical distance between the two outer curves. These fixed costs are based upon the following assumptions: (a) Bond interest and taxes, 7 per cent.; (b) sinking fund, equivalent to 6.43 per cent. depreciation, 4.2 per cent; (c) total fixed charges on capital cost, 11.2 per cent. Depreciation determined by summing the depreciation on the several parts of the plant, as follows: Building, 3 per cent.; boiler plant and coal-handling apparatus, 10 per cent.; condensing plant, 6 per cent.; generating plant, 7.5 per cent.; general average, 6.43 per cent.

From these curves the total cost of power at the present station loading factor, 24 per cent., is 0.79 cent per kilowatt-hour. At 33 per cent. loading factor the total cost would be 0.57 cent per kilowatt-hour, and at a possible loading factor of 50 per cent., 0.41 cent per kilowatt-hour. This, Mr. Bibbins ventures, is a result which it will be difficult to duplicate in any station of expensive construction burning the medium grade of bituminous coal at a cost in the neighborhood of $2.25 per ton. It is the ultimate result that proves the correctness of the engineering principles involved in the design of the station.

The Removal of a Rock Barrier in the river Clyde has just been completed. The "Elderslie Rock," as it was called, was a ridge 900 ft. long and 300 ft. wide extending obliquely across the river, and 8 ft. below low water. In 1880 the first steps were taken for its removal, the channel being given a depth of 20 ft. over it at low water. Subsequent work deepened the channel to 23 ft., and in 1903 it was decided to secure a depth of 28 ft. This work has now been completed, and in addition the channel, which was to have been 200 ft. wide, has been made 230 ft.

Concrete Fences on Station Platforms of the Brighton Beach Line, Brooklyn, N. Y.

Solid monolithic fences consisting of cement plaster covering Truss Metal lath have been built on the platforms of six of the new stations on the Brighton Beach Line, which is operated by the Brooklyn Rapid Transit Co., Brooklyn, N. Y. The improvements which necessitated the new stations and some general data regarding them were given in The Engineering Record of May 18, 1907. The platforms are of reinforced concrete slabs carried by beams and girders of the same material, and are covered with a granolithic finish. The fences referred to are the guard railings on the outside and ends of the platforms, the stations where they are used being on the embankment section of the road.

The fences running the length of the platforms, which are 240 ft. long, are 4 ft. 6 in. high, and 2 in. thick, and are surmounted by a railing 4⅝ in. high and 5 in. wide. The reinforcement consists of Truss Metal lath of No. 28 gauge. It has a cross section of 0.18 sq. in. per foot of width and weighs 67 lb. per 100 square feet. The lath is 1 in. high, so that the minimum plaster thickness covering the metal on each side is ½ in., though of course the plaster entirely fills the convolutions of the lath.

The lath is carried in continuous sheets through the whole length of the fence, and is not broken at the posts. The latter which are on 10 ft. centers are reinforced with four ½-in. rods set deep into the concrete platform. The post is formed by two short pieces of lath bent in the shape of channels and placed around the reinforcing rods, one channel on each side of the continuous sheet which forms the reinforcing of the panels. The plaster has been similarly carried around the lower parts of the steel canopy supports by short pieces of lath bent in channel shape. The posts measure 9 in. long and 8½ in. wide at the base, tapering somewhat toward the top in the width. The railing is reinforced by two ⅜-in. rods running longitudinally and by a strip of lath laid horizontally.

The intermediate panels between the posts are formed by putting on an extra ½-in. thickness of plaster for the raised part of the panels.

The platforms were completely cast before the fences were started and blocking was inserted to form a trough in which the fences were to be set. After they had been built the joint between them and the platform was covered by carrying the 1-in. granolithic finish up a quarter round curve onto the bottom of the fence. The rods for the posts were set when the platforms were built.

In constructing the fences the lath was held in place by studding of 1-in. angles supported by braces. The plaster was then put on from the side opposite the studding, and after it had set the studding and braces were removed and the other side was finished. The plaster was made of one part of Atlas Portland cement, and two parts of sand.

The fences were erected by the Truss Metal Lath Co., New York, under the direction of the engineering department of the Brooklyn Rapid Transit Co.

Snow Loads on Roofs may considerably exceed the values usually allowed for them in designs, according to investigations made last winter by S. de Perrot, of Neuenburg, Switzerland. It was observed that after a heavy fall of snow, a succession of thawing and freezing periods followed by more snow produced masses of snow and ice 24 to 30 in. thick and weighing 70 to 100 lb. per square foot of roof, which is three to four times the value usually assumed. Several such accumulations of snow and ice were found to weigh 36 to 38 lb. per cubic foot.

The British Road Tarring Trials.

Brief mention has been made in this journal of the competitions carried out during the last year at Staines, England, by the Roads Improvement Association to ascertain the best substance to spray on roads as a dust preventive and the best machine for doing this work. The tests of the machines were made on roads of broken granite, flint and gravel, but the preparations were applied only on the granite road. The judges were men of the highest standing among British road engineers, technical chemists and automobile enthusiasts, who have just made their report, which the "Journal of Gas Lighting" has reviewed as follows:

After setting forth the circumstances which led to their appointment, the judges explain that unfavorable weather militated against the carrying out of the trials as originally arranged. It is generally accepted that an application of two coats of tar is necessary for preserving the surface of a road, and the judges were desirous of carrying out the trials under this condition; but this, for the reason mentioned, could not be done. It could not be expected, therefore, that the surfaces treated with one coat only would be durable; and the judges explain that the trials in respect of durability do not reflect on the machines competing. The final judgments and awards in the machine competition were based upon the machines only. However, in spite of the generally unfavorable nature of the weather, they say the results, on the whole, may be considered satisfactory, and much useful information has been obtained in connection with the comparative merits of the various materials used and of the methods of spreading them. They consider that enough has already been done to show that "machinery can be successfully applied for this purpose, and that by the use of such machinery tar spreading can be carried on with great rapidity after preliminary preparations have been made." The judges say the cost of spreading tar by machinery has worked out at a far lower figure than the cost of applying the same quantity of the material by hand.

Tar-Spreading Machines: Aitken's Patent Pneumatic Tar-Sprayer. The judges consider this to be a well constructed machine, possessing many important advantages. It is self-contained and can be moved rapidly from one part of the road to the other. It can also cover a considerable superficial area of road in a day's work. Its construction is solid and well thought out, and the cost of working and maintenance may be expected to be low. The judges believe that by the use of this machine, under the most favorable conditions, the actual cost of laying on one coat of tar in a sufficient quantity may be cut down to almost 1-50th of a penny per superficial yard, or with a road 6 yards wide to approximately £1 per mile. This includes everything that ought to be charged to the cost of the operation, interest and sinking fund on the plant employed, a fair sum for upkeep and ample allowances for fuel and labor, but is exclusive of the cost of tar. Though in point of rapidity of working and excellent mechanical construction the judges put this machine at the top of the list, in some respects the results of the spreading were not so satisfactory as in other cases. This arises from the fact that the distributor was not properly adjusted. The judges have decided to award the first prize of 100 guineas and the Association's gold medal to this competitor.

Emulsifix, Limited. This machine is of the nature of a special form of water-cart, having means for mechanically mixing tar and tar oil with a certain proportion of water, and spraying the road before the mixture has time to separate. Although the judges are informed that this competitor put an additional application on to the road shortly after the actual trials, yet little or no trace of the application was to be seen shortly afterward. It should be mentioned that this competitor intimated that it was impossible for his machine to use the standard tar as supplied by the Association to the other tar-spreading machine competitors; and, under the circumstances, the judges allowed him to bring his own material.

Johnston Lassailly Patent Tar Road-Binder. This machine consists of a separate portable boiler for heating the tar up to 200° C. or over, from which the heated tar is transferred to distributing carts fitted with trailing brushes for evenly spreading it. The work done by this apparatus was good. A heavier coat of tar was put on than in the other cases, and, chiefly owing to this, the durability of the coating has been greater than in the case of any of the other competitors. Against this must be set the consideration that the machinery is cumbersome to handle, the working consequently slow, and therefore more costly than that of other competitors.

Tarmaciser, Limited. Owing to an accident on the road en route to the scene of the trials, this machine was unable to compete. With a view of ascertaining its comparative merits, a special test was arranged and subsequently took place on the road between Swanley Junction and Farningham, in Kent. This trial was, of course, quite independent of the tests for the competition awards. The machine did not come up to its proof. It required a considerable amount of adjustment prior to starting, and then partially broke down while at work. Though there are probably possibilities for this machine, the judges are of opinion that it cannot at the moment be considered an entirely practical apparatus.

Tarspra, Limited. This company entered three machines. The first was a 700-gal. Thornycroft motor van, and resembled in some respects the Aitken machine. This competitor entered a 1,000-gal. van, which was drawn by a small tractor. The third machine entered was a 200-gal. cart drawn by horse power. In all cases the principle of spreading the tar was the same. All three machines worked well and spread the tar evenly. The 700-gal. Thornycroft motor van is well designed. The workmanship is not quite equal to the Aitken machine, and probably the cost of upkeep will be greater. It should be mentioned, however, that different sets of nozzles can be used with these machines, and the number of square yards covered per gallon of tar can be adjusted to suit the road surface or the wishes of the person treating the road. The judges have decided to award the 700-gal. Thornycroft Tarspra machine the second prize of 50 guineas and the Association's silver medal.

Thwaite Anti-Road-Dust System. This consists of a portable tar-boiler, which holds 300 gals. of tar, and this competitor's principle is to raise the tar to a high temperature, and consequently it does not require so much pressure to lay it on the road. The judges were impressed by the good working of this machine, which seems to be simple and effective. The first cost of the apparatus is very moderate, but operating costs are not so low as the Aitken or Tarspra.

Reeson's Patent Machine. This apparatus is for putting on a preparation of tar, but it was not entered for the tar-spreading machine competition. It consisted of a tank fitted with gravitation sprinkler and two rotary brushes. At a special test of this machine on the road between Swanley Junction and Farningham, Kent—at the same time as the special tests of the Tarmaciser were made—it worked satisfactorily, and was very favorably commented upon. The heating arrangement consisted of a Wells light burner, paraffin being the heating agent. The air pressure for this heater was obtained by means of a hand pump.

Preparations of Tar. The preparations of tar tested were of two classes—(1) those containing very little tar, and (2) those in which tar formed the main ingredient.

In the first class were the compounds "Crempoid R," "Crempoid D," "Ermenite," "Hahnite," and "Pulvicide." The results of treating the roads with all these compounds may be dismissed in a brief paragraph. Within a very short time after their application—*i. e.*, a week in the case of "Ermenite," a fortnight in the case of the "Crempoids" and "Pulvicide," and a month in the case of "Hahnite"—they had practically disappeared. The compounds have not the durability of tar, and the judges do not consider their use as economical. Moreover, complaints have been received to the effect that the dust raised from the sections of the roads treated with some of these materials is injurious to the eyes of those using the roads and to the frontagers living along their routes.

The preparations containing a large proportion of tar were, on the whole, very satisfactory. We deal with them in their order of merit.

Clare's Patent Tar Compo. This was applied to a quarter-mile section of road extending from the steam laundry at Staines to a point a quarter-of-a-mile eastward from the same laundry by one of the smallest of the "Tarspra" machines, similar in type to the 200-gal. one entered in the tar-spreading machine competition. This section of road, as regards dryness of surface, was approximately in the same condition as the other lengths. The macadam was in good condition. The quantity of the material appears to be 1 imp. gal. to 7 sq. yd., applied in two coats. At the price quoted by the competitor—3½d. per gallon delivered in London—and after making allowance for getting the material into position on the road, it works out, excluding the cost of spreading, for a coating of 7 sq. yd. to the gallon, at 0.57d. per square yard of road surface, or approximately £25 per mile of road 6 yd. wide. From the time of laying until recently it has been uniformly good, and is now in better order than any other portion of the road. The surface is wearing rapidly, especially in the center. The judges have decided that the Ballymenagh 100-guinea trophy and the gold medal of the Association for the best preparation of tar for road purposes be awarded to Messrs. Clare & Co., of Liverpool. The smell of the material is relatively evanescent and unobjectionable.

In the judges' opinion the success of the Clare Company's compo is greatly due to the fluidity obtained. When applied cold (as recommended by the manufacturers), as was the case on the Staines Road, the penetration was very considerable. In spite of this, the tar has body enough to hold together in a highly satisfactory manner the small dust-forming particles. Moreover, it has been ascertained that the cost of treating or adding to tar by this method is not considerable, and is far more than compensated by the extra penetration, as described above. The preparation flashes at ordinary temperatures, and special care must be exercised to avoid risk of firing during treatment.

Oil-gas tar was entered by the Gaslight & Coke Co. This material was applied to a length of road adjoining that of the Clare Co. by a special form of machine devised by the Gaslight & Coke Co.'s engineer, Mr. Reeson, which is commented upon under the heading of "Tar-Spreading Machines." This length of road is in a fairly good condition. Oil-gas tar probably penetrates deeper than anything else, but it does not form so durable a wearing surface, and consequently is not so great a protection to the face of the macadam as a good tar preparation. It is not a new substance and has in the past been used in various places, but the actual material entered by this competitor is understood to have been a specially treated oil-gas tar, from which the more readily volatile and low-flash constituents of ordinary oil-gas tar have been removed. The smell of the preparation was penetrating and of the same character as that of ordinary oil-gas tar, but less strong and persistent. It would probably be very useful for the purpose of giving a first coat to a road, to be followed by one of coal-gas tar or similar substance.

T. G. Marriott's "Marbit." The third in order of merit of the competing preparations is "Marbit," entered by this competitor, but the condition of the section of the road treated is not quite so good as that of the first two named.

Tar Supplied by the Association. In addition to the competing preparations, it is necessary to make some mention of the various kinds of tar supplied by the Association for comparative purposes.

1.—This was a new crude coal tar, which had merely undergone the ordinary mechanical separation process, supplied by the South Metropolitan Gas Co. for the use of the tar-spreading machines on the Staines and Hounslow granite road and the Twickenham and Kempton Park flint road. The judges consider that, though this was a fair average specimen of tar, it did not yield satisfactory results unless applied in quantity in excess of that found necessary in the case of the Clare patent tar compo. One gallon of the Clare material has given an exceedingly good surface to 7 sq. yd. during the summer months, whereas in this case quite 1½ times the quantity is required to give equal results, which greatly affects the total cost of the completed operation.

2.—This also was crude coal tar which had undergone the ordinary mechanical separation process, supplied by the Reading Gas Co. for use in the tar-spreading machines at Ascot. It was far inferior for road purposes to that supplied by the South Metropolittan Gas Co. It was apparently unsuitable for spraying in the machines, probably owing to the foreign matter which it contained when it arrived in the tanks at Ascot.

3.—This was a "refined" or "freed" tar from the South Metropolitan Gas Co., and was kindly supplied by the company for experimental purposes free of cost to the Association. This was also laid upon the road by a 200-gal. Tarspra cart. This is a coal tar from which the water and naphtha have been distilled, and has a specific gravity of about 1.24. The distillation serves to remove the ammonia, which is an objectionable constituent of tar for road treatment, and the light oils. The cost of this tar is about ¼d. per gallon above the same company's market price for crude coal tar. The preparation answered well in the trial.

4.—This was an ordinary refined coal tar from the tar distillery, as supplied by Messrs. Burt, Boulton & Heywood, of Silvertown. This material was applied by a 200-gal. Tarspra cart, similar to the one entered in the tar-spreading machine competiton, on a section of the Staines and Hounslow granite road. The specific gravity is about 1.21. The net cost at the wharf is about 3d. per gallon. For some reason this tar did not answer quite so well as the somewhat similar preparation from the South Metropolitan Gas Co., but it was fairly satisfactory.

5.—This was a blast-furnace tar, supplied by Messrs. R. & A. Reid, of Glasgow. It was applied to a section of the granite road between Hounslow and Staines by a 200-gal. Tarspra cart. The tar is derived from blast furnaces using splint coal in the neighborhood of Glasgow, and therefore offers a supply entirely independent of gas works. Its specific gravity is 1.1, but it is highly vicious and needs considerable heating to make it sufficiently fluid for laying on the road. Its smell is rather objectionable and persistent. The cost in London is 2¼d. per gallon, but appreciably less in the North. In order of merit it comes after the refined gas tars.

Judges' Observations. Speaking generally, the whole of the machines tested showed considerable originality and forethought in design, and considering the short time the demand for this machinery has been before inventors, the results obtained are exceedingly promising. No doubt most of the machines exhibited can be improved, and when using the proper material in correct quantities they are all likely to give satisfactory results. Suitable tar compositions are practically insoluble, yield no matter liable to be washed away into the watercourses to pollute and to cause damage, nor should there be any considerable quantity of tar-dust ground off the road surfaces after treatment. The judges believe that the complaints made under this head previous to these trials have been due to the use of improper materials—that is, tar from which the more unsuitable compounds have not been extracted previous to it being used on the road. Now that this is understood, it is probable that most of these difficulties will disappear.

It will be noticed that little has been said in this report as to the Ascot experiments. The judges consider that this portion of the work was not satisfactory, for several well understood reasons. In the first place, the tar supplied from the Reading gas works was apparently unsuitable for spraying by machinery. Through some unexplained cause, a great deal of foreign matter found its way into the tar, which blocked the nozzles of the machines and caused very irregular working. Moreover, as regards the dampness of the road material, the road surface at Ascot compared very unfavorably with those at Staines nad Twickenham. Some heavy rain had fallen in the night previous to the experiments, and the road being greatly sheltered by trees the moisture did not dry out. It was therefore not to be expected that the tar would adhere to the surface of the road, and in consequence it could be seen that in many cases the tar, instead of penetrating, was lifted off by traffic in the form of a detached film, leaving the road unprotected.

Book Notes.

All engineers who keep in touch with technical writings in German and French will regret to learn that the Society of German Engineers has resolved to discontinue work on the "Technolexicon," the great technical dictionary in German, French and English, which it has been engaged in preparing for several years. The director of the society reports that the work has turned out to be far more expensive than anyone anticipated and the cost of carrying it through to completion within the allotted time far exceeds pecuniary resources available for the purpose. It has always seemed to this journal that the enterprise was one of such magnitude that it was hardly practicable on the scope proposed by the society, although the latter is the largest engineering body in the world. Few people who have not actually taken part in the preparation of a high-grade lexicon have any appreciation of the enormous amount of skilled work required to carry through such an undertaking, entirely apart from the labor of the technical experts who take part in the authorship. The society has not announced in what condition the matter is at the present time, and it is to be hoped that the work has progressed to such a state that some of the enterprising German publishers may be willing to take hold of the data already collected and publish a technical dictionary, not so comprehensive as that proposed by the society, but still more modern and accurate than those now available.

A book that will be found particularly valuable by all interested in public health has just been published under the title of "Sanitation of Public Buildings," the author being Mr. Wm. Paul Gerhard. This work is, in a sense, a continuation of the same author's well-known book, "Sanitary Engineering of Buildings," which is devoted largely to the sanitary work in dwelling houses, apartments and tenements. In the new book the author discusses the drainage, water supply, lighting and ventilation of hospitals, theatres, churches, schools, markets and abattoirs. While the book is a thoroughly practical one, it is also based on the most advanced theories accepted generally by sanitary specialists of Europe and this country. There is probably no other book in the English language which so thoroughly covers the subject of sanitation in public buildings as this. (New York, John Wiley & Sons, $1.50.)

Dr. W. K. Shepard, of the Sheffield Scientific School of Yale University, has prepared a volume of "Problems in Strength of Materials" which will doubtless be of material assistance to teachers of the subject. Nobody can hope to master a subject of this nature who is unwilling to spend time in solving well-selected problems, any more than a person can hope to become a lawn-tennis expert by reading a book concerning that sport. This is so well recognized in most schools that recitations are carried on very largely today by means of the solution of problems. This volume should be of material help to the instructor in helping him to obtain a wide range of such examples. In addition to the classroom use of the book, it should prove of value to those engineers who are accustomed to spend a little time every day in solving one or more exercises in branches of engineering work with which they are not directly connected at the time. (Boston, Ginn & Co., $1.30.)

About a year ago a review was printed in these pages of the excellent treatise on "Producer Gas," by Messrs. J. E. Dodson and A. T. Larter. Naturally enough this volume has been very warmly received by engineers and it has been accordingly necessary to bring out a second edition. The revisions which have been made have been mainly in the chapters relating to suction gas plants, although some new illustrations have been added in other portions and additions made in the text in many places. The book is unquestionably the most comprehensive work on the subject that we now have, and any engineer who contemplates putting in a producer plant for heating or engine work will find in the volume a large amount of useful information. (New York, Longmans, Green & Co., $3.00.)

Letters to the Editor.

TEMPERATURES DESTRUCTIVE TO CONCRETE.

SIR: We are rather interested in knowing the highest temperature that concrete construction has been able to withstand without cracking or crumbling. Can you secure this for us? Yours truly, BLAW COLLAPSIBLE STEEL CENTERING CO.

Pittsburg, Oct. 28.

[This inquiry was submitted to Prof. Ira H. Woolson, of Columbia University, who has kindly furnished the following information:

"Replying to the inquiry relative to the ability of concrete to withstand heat without crumbling or cracking, I would say that I have conducted a considerable number of tests in an investigation of this proposition in connection with the work of the joint-committee of the American Society for Testing Materials. The results of those tests were presented to the Society in three papers, the first in 1905, the second in 1906, and the third this past summer. The paper of this year was devoted largely to an investigation of the thermal conductivity of trap, gravel, and cinder concrete, as the work of the previous years had demonstrated that the non-conducting properties of concrete was the reason of its ability to withstand high temperatures.

"Although there were a few instances where trap rock concrete cubes were heated to a temperature of 1500° without showing serious deterioration in strength, my own judgment is that the result of all the work shows that if concrete is heated throughout to a temperature of 1000° to 1500° F., it has lost the major portion of its strength and is very likely to crack and crumble if allowed to stand undisturbed. This is particularly true of quartz gravel concrete. In many cases a thorough heating to a temperature of 750° will reduce the strength of the concrete to a large degree. On the other hand, it is a well known fact that concrete will withstand a temperature of 1500° or over for an hour or two when heated on one or two sides only, and will still be in excellent condition. The reason for this is plainly shown in the paper on thermal conductivity above referred to, in which it was demonstrated that a concrete could be heated on one face at a temperature of 1500° F. for an hour and the temperature of the interior two inches in from the heated face with a rise of only 200° or 300°.

"In that paper I drew the following conclusions from my investigations: First, that all concrete mixtures when heated throughout to a temperature of 1000° to 1500° F. will lose a large proportion of their strength and elasticity, and this fact must be well remembered in designing. Second, that all concrete has a very low thermal conductivity and therein lies their well known heat resisting properties. Third, that as a result of this low thermal conductivity, 2 to 2½ in. of concrete covering will protect reinforcing metal from injurious heat for the period of any ordinary conflagration (provided, of course, that the concrete stays in place during the fire). Fourth, that reinforcing metal exposed to the fire will not convey by conductivity an injurious amount of heat to the embedded portion. Fifth, that quartz gravel concrete is not a reliable or safe fire resisting aggregate."

There is so much interest shown just now regarding the effect of successive increases in temperature on the compressive strength of concrete that a series of tests with different grades of concrete subjected to different temperature up to 1000° will be likely to yield information of general value.—Editor.]

The Status of Manual Training.

Sir: The letter from "C. E.," of Boston, on the relations of the public school to industrial education in your issue of Nov. 16 leaves the present status of manual training somewhat uncertain. In fact, in many minds there is not a clear differentiation between vocational and manual training. Through ignorance the former has been here and there regarded as superior to and the possible successor of the latter. In point of fact, however, the manual training school is accepted among leading educators as only one of the essential elements in a complete educational system, the vocational or trade school being recognized as entirely independent in purpose, organization, and curriculum.

Following close upon the report of the Superintendent of the Boston schools, referred to in the above-mentioned letter, there has just been made public a document which proclaims the status of the manual training school in general, and of the Mechanic Arts High School of Boston in particular. It is in the form of a report made at the request of an investigating committee known as the Finance Commission. That it must be accepted as authoritative, and is certain to attract wide attention, is evidenced by the names signed thereto. They are Charles W. Eliot, President of Harvard College; Henry S. Pritchett, late President of the Massachusetts Institute of Technology, and Rev. Fr. Thomas I. Gasson, who is President of Boston College.

The question propounded to them was as follows: "The City of Boston has, for the current year, a million dollars to spend in land for the Phillips district and various buildings. Taking into account the needs of both the elementary and the high school education, is it wise to spend approximately $500,000 out of this million in rearranging the present Mechanic Arts schoolhouse and erecting a large addition to it?"

In their reply the special committee assume as admitted the following fundamental principles regarding the conduct of public education in a municipality: (1) That it is the plain duty of a municipality, such as Boston, to support, and support generously, high school education as well as elementary education. (2) Under modern conditions, it seems equally clear that a municipality must support several kinds of high school education, adapted to the various needs and desires of its population. The city of Boston to-day supports Latin High Schools, English High Schools, the Mechanic Arts High School and the Commercial High School. All these give a general education, but guide their pupils in different directions.

In seeking to answer the given question, the Committee made an exhaustive examination of statistical information regarding cost of building, equipment, instruction, etc., as well as of records of graduates. But they recognized that their decision was to be based not alone on statistical data, but also on certain fundamental considerations concerning the character of the education provided by the Mechanic Arts High School. Its work is thus described:

"The Mechanic Arts High School is an institution in which the elements of the mechanical arts are taught in connection with a thorough academic course, rich in mathematical and scientific subjects. Its fundamental object is to promote general culture, but the specific training which it gives is excellent preparation for many mechanical pursuits. It teaches the principles and processes which underlie many trades; but it is in no sense a trade school. The time which is devoted to any branch of mechanical work is entirely inadequate to give the knowledge and skill required by a journeyman. Moreover, the educational value of a shop exercise is determined by the thought which the pupil must bestow upon it; consequently no operation is repeated mainly for the purpose of increasing skill; but a new problem is presented as soon as the difficulty of a given process is fairly mastered. The most important function of the school is to reveal to boys, through its many-sided activities, their dominant aptitudes and help them to lay a firm foundation for the work for which they are best fitted. It aims to discover how executive and creative ability can be most effectively stimulated, diversified and directed. This ability is one of the most important factors in our complex civilization. Some men show it by excellent work at the bench, others at the drawing board, and others as foremen, overseers, superintendents, engineers, or organizers of industries. The school which opens the door of opportunity in a wide range of industrial activities is vocational in the largest and best sense of the term. In this age, characterized by a marvellous development of industries based upon scientific and mechanical principles, such a school meets a highly important and pressing need of the community."

It is made evident that it is not a trade school, nor does it send out young men who are likely to become journeymen in the various trades. Its purpose is to give a general education, with such training in the mechanical arts as will suggest to its pupils industrial pursuits.

This purpose is manifestly entirely different from that of an industrial school or a trade school. For example, the new Franklin Union, and the Wentworth School to be established in Boston are to be schools in which the theoretical foundation of many trades is to be taught at night to such men, already in the trades, as desire such instruction. The committee assert that the existence of these schools, which are for entirely different objects from those of the Mechanic Arts High School, have no bearing on the question.

The records show that during its fourteen years of existence the graduates of the school have gone mainly into pursuits suggested by the mechanical instruction which they have received. Some of them have entered high-grade engineering schools and become engineers. A larger number have filled the position of draughtsman. Others have become foremen. In general a strong tendency has been developed to engage in those occupations which look toward the producing side of business life. A reasonably large number have come into executive places by proving their administrative ability in mechanical positions. Speaking broadly, the records of the graduates show that the school is accomplishing its purposes.

A considerable number of graduates of the school enter the Massachusetts Institute of Technology, although this number constitutes but a small percentage of all the students who enter the school. The records made by these students at the Institute have not in the past equalled those made by students from the best suburban high schools. It appears, however, that very few of the youths who enter the Mechanic Arts High School do so with the thought of going to a school of technology later. The choice of an engineering career is the result in most cases of the student's experience in the school, which inspires the ambition to enter an engineering profession.

The school is now attended by nearly eight hundred pupils, although only about three-fourths of that number are satisfactorily seated. In light of this fact, and of their general attitude toward the entire subject of manual training, the committee unanimously conclude:

1. That the Mechanic Arts High School fills a useful purpose by opening to the youth of Boston new ways toward good livelihoods.
2. That additional facilities must be furnished, if those boys who wish to avail themselves of this form of education are to have the opportunity to do so.
3. That this need is now more urgent than that of any other specific addition to the school system of Boston.
4. That it is, therefore, expedient for the city to proceed with the enlargement of the Mechanic Arts High School without delay.

This report, local though it is in its primary application, but rendered by educators of such recognized standing, must be accepted as fully establishing the present status of the manual training school as a vital element in our educational system. It distinctly differentiates between manual and vocational training, and recognizes the independent field for the introduction of educational courses looking to the development of the journeyman in the various trades.

Walter B. Snow.

Boston, Nov. 7, 1907.

The American Coke Industry during the last three years has been marked by a steady decrease in the consumption of coal per unit of coke, due for the most part to the development of by-product manufacture, in which the yield of coke from the coal is considerably greater than in the beehive oven. The figures for the calendar year 1906, compiled for the U. S. Geological Survey by Mr. E. W. Parker, show that the total value of coke produced was $91,600,000, the average value per ton being $2.52.